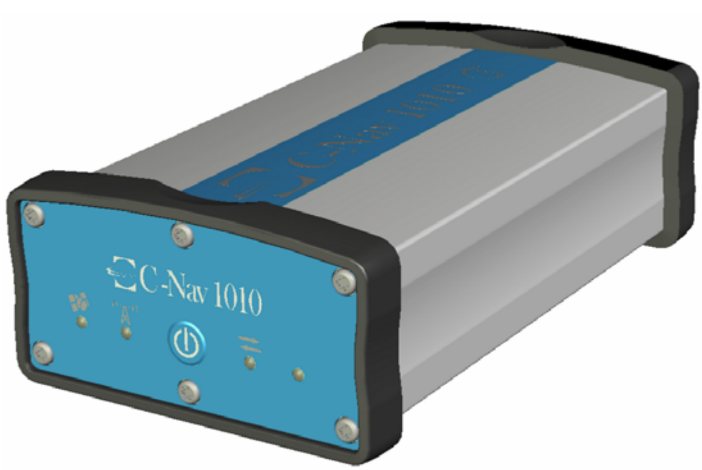
C-Nav 1010 GNSS RECEIVER

User Guide



C-Nav® World DGNSS
730 East Kaliste Saloom Rd.
Lafayette, La. 70508 USA
Tel: +1 337 210 0000
Fax: +1 337 261 0192
E-mail: *cnav.support@cnavgnss.com*

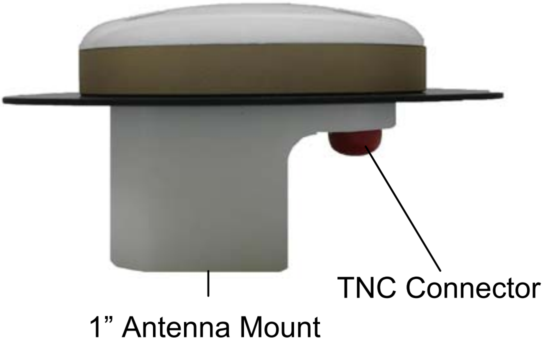
C-Nav® WORLD DGNSS

Quick Start Guide

Follow this Quick Start Guide to set up the standard configuration of the C-Nav1010, designed for productivity with minimal setup time.

Hardware Connect

Connect the supplied Positronic 9-pin connector of the serial cable to Port A or Port B of the C-Nav1010. Connect the DB9 end to the PC.



Mount the supplied L1/L-band antenna to a mast, as described in *Chapter 3*. (Ensure the antenna is in an area with a 360º view of the sky).

Connect a GPS antenna cable to the GPS antenna. Connect the other end to the TNC connector, labeled ANT 1, on the receiver.

C-Nav1010R Only: To track C-Nav Corrections Service Signals at high latitudes, mount the L-band antenna to a mast as described in *Chapter 3*. Connect a GPS antenna cable to the L-band antenna. Connect the other end to the TNC connector, labeled ANT 2, on the C-Nav1010R receiver.

Connect supplied DC power cord to 9-36VDC-power source. Refer to *Figure 4* for power cable pin assignments.

Connect the Positronic 9-pin end of the power adapter to the receiver power port.

GPS C-Nav Service On/Off Data

Depress the On/Off switch on the front panel for more than 3 seconds to power on the receiver. All LEDs illuminate for 3-5 seconds during power-up.

Your C-Nav1010 Hardware is now properly connected.

Software Setup

C-Monitor/C-Setup

After installation, double-click on the C-Monitor or C-Setup icon. Use the menu to select:

File->Open Port

Choose communications settings:

57600 baud, parity none, 8 data bits, 1 stop bit Press "Ok"

This software will allow you to view the positioning data in real-time and control the C-Nav1010.
For further information, see the C-Monitor and C-Setup User Guides: *http://www.cnavgnss.com/support*

C-NaviGator

After connecting the DB9 end of the serial cable to C-NaviGator, use the menu to select:

Settings->Port, and choose the port.

Select the receiver type and choose communications settings:

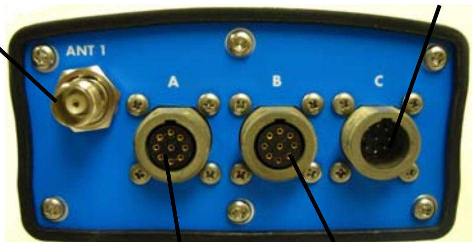
57600 baud, parity none, 8 data bits, 1 stop bit Press "Ok"

The software will allow you to view the positioning data in real-time and control the C-Nav1010.
For further information, see the C-NaviGator User Guide: *http://www.cnavgnss.com/support*

C-Nav1010M

TNC Connector 1 L1/ C-Nav Antenna

Power Port



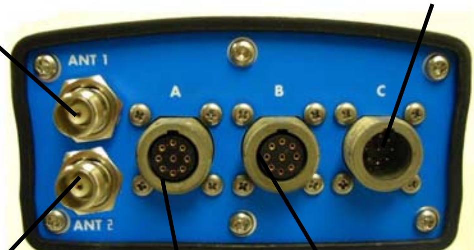
Port A RS232

Port B RS232/422 (switchable)

C-Nav1010R

TNC Connector 1 L1 Antenna

Power Port



TNC Connector 2 Optional Separate C-Nav Helix Antenna

Port A RS232

Port B RS232/422 (switchable)

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C-Nav1010 GPS User Manual
P/N: CNV96-310023-3001
Revision D
May 2011

Serial Number: _____

Date Delivered: _____

Purchased From: ____

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Trademarks

C-Nav® is a registered product of C&C Technologies, Inc. (C-Nav DGNSS). All other products and brand names are trademarks or registered trademarks of their respective holders.

FCC Notice

This device complies with Part 15 Subpart B Class B of the FCC Rules. Operation is subject to the following two conditions:

This device may not cause harmful interference, and;

This device must accept any interference received, including interference that may cause undesired operation.

User Notice

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This limited warranty period is one (1) year from date of purchase.

C-Nav Corrections Service Licensing

The C-Nav signal requires a subscription that must be purchased to gain access to the service. Licenses are non-transferable, and are subject to the terms of the C-Nav Corrections Service License Agreement. Subscriptions are based upon a predetermined period of usage. Subscriptions can be left to expire, or if service is no longer needed prior to the date of expiration of service, a deactivation code can be obtained by contacting C-Nav at: *cnav.support@cnavgnss.com* or via *www.cnavgnss.com/code*

For further details on the C-Nav Corrections Service Signal Network, subscriptions, deactivations, terms, conditions and its capabilities, refer to *Appendix C* of this manual or send an email inquiry to *cnav.support@cnavgnss.com*

USG FAR

Technical Data Declaration (Jan 1997)

The Contractor, C&C Technologies, Inc. hereby declares that, to the best of its knowledge and belief, the technical data delivered herewith under Government contract (and subcontracts, if appropriate) are complete, accurate, and comply with the requirements of the contract concerning such technical data.

Global Positioning System

Selective availability (S/A code) was disabled on 02 May 2000 at 04:05 UTC. The United States government has stated that present GPS users use the available signals at their own risk. The US Government may at any time end or change operation of these satellites without warning.

The U.S. Department of Commerce Limit Requirements state that all exportable GPS products contain performance limitations so that they cannot be used to threaten the security of the United States.

Access to satellite measurements and navigation results will be limited from display and recordable output when predetermined values of velocity and altitude are exceeded. These threshold values are far in excess of the normal and expected operational parameters of the C-Nav1010 GPS Sensor.

Revision History

Rev D (May 2011)	Removed 1PPS references. Added DGNSS references.
Rev C (Sept 2008)	Revised L-band correction signal table to reflect new INMARSAT Satellite Location changes. Removed references to 44 message.
Rev. B (May 2008)	Initial Release.

Use of this Document

This User Guide is intended for use by someone familiar with the concepts of GPS and satellite surveying equipment.

Note indicates additional information to make better use of the product.

This symbol means Reader Be Careful. Indicates a caution, care, and/or safety situation. The user might do something that could result in equipment damage or loss of data.

This symbol means Danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical and RF circuitry and be familiar with standard practices for preventing accidents.

Revisions to this Users Guide can be obtained in digital format from *http://www.cnavgnss.com*

Related Documents

C-Nav1010 Technical Reference Manual

P/N: NAV96-312006-3001

Describes the control and output data message formats utilized by this instrument (for customer programming purposes; contact *cnav.support@cnavgnss.com* to obtain a digital copy).

C-Nav Online Resources

Includes the latest software/firmware updates, users manuals, FAQs, Satellite Calculator and help files for all C-Nav products: *www.cnavgnss.com*

Related Standards

ICD-GPS-200

NAVSTAR GPS Space Segment / Navigation User Interfaces Standard. ARINC Research Corporation; 2250 E. Imperial Highway; El Segundo, California 90245

RTCM-SC-104

Recommended Standards For Differential GNSS Service. Radio Technical Commission For Maritime Services; 1800 N. Kent St, Suite 1060; Arlington, Virginia 22209

CMR, CMR+

Compact Measurement Record; Trimble Navigation Limited; 935 Stewart Drive; Sunnyvale, CA 94085

NMEA-0183

National Marine Electronics Association Standard For Interfacing Marine Electronic Devices. NMEA National Office; 7 Riggs Avenue; Severna Park, Maryland 21146

Publicly Operated SBAS Signals

RTCA/DO-229D

The Radio Technical Commission for Aeronautics (RTCA) develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management (CNS/ATM) system issues.

RTCA. 1828 L Street, NW, Suite 805, Washington, DC 20036.

These organizations implement the RTCA/DO-229D standard set by RTCA:

WAAS

(Wide Area Augmentation System)

U.S. Department of Transportation. Federal Aviation Administration. 800 Independence Ave, SW, Washington, DC 20591

EGNOS

(European Geostationary Navigation Overlay Service)

European Space Agency. 8, 10 rue Mario-Nikis, F-75738 Paris Cedex 15, France.

MSAS

(MTSAT Satellite-based Augmentation System)

Japan Civil Aviation Bureau. Ministry of Transport. Kasumigaseki 2-1-3, Chiyoda-ku, Tokyo 100, Japan.

GAGAN

(GPS Aided Geo Augmented Navigation)

Indian Space Research Organization. Antariksh Bhavan, New Bel Road, Bangalore – 560 094, India.

Contact Information

If you have a problem and cannot find the information you need during the installation or operation of a C-Nav DGNSS product, contact:

C-Nav Support:

Phone: +1 337 210 0000 (24/7 support)
Fax: +1 337 261 0192

Phones are answered 24 hours, 7 days a week, with on-call technical support engineers available.

E-mail: *cnav.support@cnavgnss.com*
Web: *http://www.cnavgnss.com/*

C-Nav Technical Support normal operational hours are 7am to 5pm, Monday through Friday Central US Standard Time. In addition, our regional offices can provide first line support for the C-Nav DGNSS System.

To expedite the support process, please have following information available:

1. The product type and model number(s)
2. The Serial number(s)
3. The software or firmware version number(s)
4. The LAT/LON position of operation
5. Your specific question or problem.

Please provide detailed background information, such as the configuration of your system, the actual receiver parameters of operation, and the exact type, make, and configuration of your computer and navigation software in use.
If you have received error messages, please specify the exact wording.

If you need to send a data file along with your inquiry, please compress the file using PKZIP or WINZIP Software and name the file with the extension .ZIP. Use one of the following methods to send the data file:

• Attach the file(s) to your email inquiry to *cnav.support@cnavgnss.com* The file attachments must be less than 5Mb in size in order for them to be received via the C&C Technologies, Inc. mail-server.

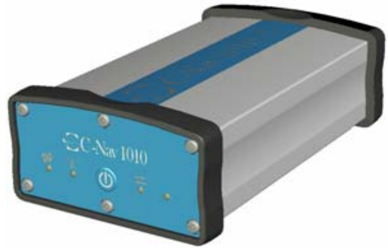
• Place the file on an open FTP site and include the 'link' to the filename in your email (or telephone) inquiry so that C-Nav Support can retrieve the file(s).

In the event that your equipment requires service, we recommend that you contact either your regional agent or C-Nav DGNSS Office to obtain a Return Material Authorization (RMA) number before returning any items or products. A fault or failure description will be required before C-Nav will issue an RMA number that must be used to identify and track all returned equipment.

Chapter 1 Introduction

System Overview

GPS Sensor System



The C-Nav1010 GPS sensor delivers unmatched accuracy to the precise positioning community. This unique receiver is designed to use the C-Nav Corrections Service Network, which is a worldwide Satellite Based Augmentation System (SBAS) for half meter level position accuracy (post-convergence period). The receiver is capable of RTCM code and DGPS operating methods. The operating software is also capable of supporting an external radio modem.

The C-Nav1010 integrated sensor consists of:

14-channel, L1-frequency, precision GPS receiver

2 separate SBAS channels, RTCA/DO-229D compliant (WAAS, EGNOS, MSAS, GAGAN)

C-Nav Corrections Service L-band receiver

There are two models, the C-Nav1010M and the C-Nav1010R. Packaging and performance standards of the models are the same; the difference lies in the inclusion of the L-band antenna with a built-in LNA with the C-Nav1010R, as described later in this chapter.

The system also includes a wide-band antenna with a built-in LNA and other interconnection accessories outlined in *Table 1* later in this chapter.

Included Equipment

Figure 1*: C-Nav1010 Supplied Equipment*

Optional Equipment

Figure 2*: C-Nav1010 Optional Equipment*

***Table 1**: Supplied Equipment*

1	C-Nav1010 GPS Sensor (C-Nav1010M P/N: NAV92-310367-3003LF) (C-Nav1010R P/N: NAV92-310367-3004LF)
2	Positronic 9-Pin to DB9S Data Cable, 6' (P/N: NAV94-310260-3006LF)
3	L1/L-band GPS Antenna (P/N: CNV82-001017-0001)
4	Cable Assy, Unterminated, Power Port, 10' (P/N: NAV94-310262-3010LF)
5	L-band GPS Antenna, Helix (C-Nav1010R only, for use between 45° – 25° latitudes) (P/N: NAV82-001018-0001LF) OR, High Latitude L-band Antenna (for use at latitudes <25°) (P/N: NAV82-001003-0001LF)
6	Mounting Brackets (P/N: NAV88-310408-3001LF)
7	RS-232/RS-422 Splitter (Not Shown)
8	Shipping Carton with Label (Not Shown) (P/N: NAV79-200303-0001LF)
9	C-Nav1010 User's Guide (Not Shown) (P/N: CNV96-310023-3001)
10	Pipe Mount Adapter for L-band GPS Antenna, Helix (C-Nav1010R only, see *Figure B5*)

***Table 2**: Optional Equipment*

1	C-Nav1010 PSU w/ Power Cords, AC/DC, 12VDC, 1.5A (P/N: CNV82-030001-3003F) Includes: Positronic 9-Pin Universal AC/DC Power Adapter (P/N: NAV82-030001-3003LF) *and* 3-pin AC Power Cords (US, Euro and UK) (P/N: US 4250011-110) (P/N: Euro 4250012-220) (P/N: UK 4250013-240)
2	12" Antenna Mounting Pole (P/N: WES534610)

Models

C-Nav1010M

This model utilizes a compact dual-band antenna capable of receiving GPS and C-Nav Corrections Service signals. This antenna provides excellent phase center stability in a small, robust, lightweight format.

The model is ideal for vehicle mounting to suit a wide variety of machine guidance and control applications in: GIS (Geographic Information Systems) data collection, hydrographic surveying and Nautical Station-keeping.

It is equipped with additional features allowing interconnectivity with a variety of antennas and other instrumentation to suit specific applications and configurations.

C-Nav1010R

The C-Nav1010R is similar to C-Nav1010M, except that it includes a separate L-band antenna (P/N: NAV82-001018-0001LF for use in 45°-25° latitudes, or, NAV82-001003-0001LF for latitudes <25°) for enhanced C-Nav Corrections Service signal reception in challenging environments such as high geographic latitude.

Both the GPS antenna port (ANT 1) and the C-Nav Corrections Service antenna port (ANT 2 – C-Nav1010R only) provide 5.0VDC. Care must be taken to select an appropriately rated GPS antenna if the standard C-Nav antenna is not used.

Features That Apply to Both Models

(C-Nav1010M and C-Nav1010R)

Output Data Rate

Both C-Nav1010 models can output proprietary raw data at programmable rates from ≤1Hz to predetermined rates up to 10Hz and Position Velocity Time (PVT) data at programmable rates from ≤1Hz to predetermined rates up to 10Hz through two 115kbps RS-232 serial ports with less than 100ms latency. ≤50cm horizontal and ≤75cm vertical accuracy are maintained as each output is independently calculated based on an actual GPS position measurement, as opposed to an extrapolation/interpolation between 1Hz measurements.

NCT Binary Proprietary Data

The sensor can output proprietary raw data containing information including (but not limited to):

Satellite Ephemeris (0x81)

Raw Pseudorange Measurements (0xB0)

Position, Height, & Time (0xB1)

Velocity & Heading (0xB1)

Signal to Noise (0x86)

Channel Status (0x86)

Correction Data (mirror data; 0xEC)

Measurement Quality (0xB1 and 0xB5)

This data can be integrated in real-time positioning applications or post-processed against any number of software applications designed to handle NCT or RINEX raw data. The C-Nav1010 Technical Reference Manual describes the attributes of each of the input/output records (see *Related Documents* in the fore-matter).

NMEA-0183 Data

The C-Nav1010 is capable of outputting several standard NMEA-0183 data strings (see *Related Standards* in the fore-matter). Refer to *Appendix D* for NMEA Data Output Message Formats.

Standard (each data string is headed with GP):

ALM – GPS Almanac Data

GBS – GNSS Satellite Fault Detection

GGA – GPS Fix Data

GLL – Geographic Position – Lat / Lon

GRS – RAIM Monitoring Data

GSA – GNSS DOP & Active Satellites

GST – GNSS Pseudorange Error Statistics

GSV – GNSS Satellites In View

PNCTSET – Solid Earth Tides, Polar Tides and Ocean Loading Values

RMC – Recommended Minimum Specific GNSS Data

VTG – Course Over Ground & Ground Speed

ZDA – Time & Date

Antennas

Standard

The standard integrated antenna (P/N: CNV001017-0001LF) tracks all GPS, WAAS, EGNOS, MSAS, GAGAN and C-Nav Corrections Service signals. Our compact GPS antenna has excellent tracking performance and a stable phase center for GPS L1. The robust housing assembly features a standard 1”-14 thread for mounting and is certified to 70,000 feet (see *Appendix B* for restrictions).

L-band (C-Nav1010R only)

The L-band antennas (P/N: NAV82-001018-0001LF for between 45°-25° latitudes and NAV82-001003-0001LF for use at latitudes <25°, left to right, respectively) track C-Nav Corrections Service signals. These antennas have excellent tracking performance of geostationary satellites for latitudes furthest from the equator. The robust housing assemblies feature a flat mounting surface with three mounting holes and a TNC connector. The L-band antennas come with a pipe mount adapter for one-inch diameter pipes (see *Figure B5*). The C-Nav1010R uses the Standard Antenna to receive the GPS, WAAS, EGNOS, MSAS and GAGAN signals.

Refer to *Chapter 3* for detailed installation instructions for both Standard and L-band antennas.

Controller

The C-Nav1010 GPS sensor is designed for use with an external controller solution connected via one of two serial ports.

This may be accomplished using a PC, Tablet PC or Personal Digital Assistant (PDA) and a software program which implements the rich control language defined for C-Nav GPS products. Refer to the users guide of the controller solution for further information.

Refer to *Chapter 4* for descriptions of C-Nav Control/Display Unit and controller software options, or visit *www.cnavgnss.com/Products*

Unique Features

The C-Nav1010 GPS sensor has many unique features:

- C-Nav Corrections Service

The ability to receive C-Nav's unique correction service is fully integrated within each unit. A single set of corrections can be used globally, enabling a user to achieve half-meter level positioning accuracy without the need to deploy a separate base station, thus saving time and capital expenditure.

C-Nav position outputs are referenced to the ***ITRF2005 datum*** (April 2008).

- Positioning Flexibility

The C-Nav1010 is capable of using WAAS, EGNOS, MSAS, GAGAN (RTCA/DO-229D compliant) code corrections via two internal Satellite Based Augmentation System (SBAS) channels. The C-Nav1010 automatically configures to use the most

suitable correction source available and changes as the survey dictates (this feature can be overridden).

- **Data Sampling**

1Hz Standard, 5 and 10Hz Optional

GPS L1 raw measurement data is output up to 1Hz in the standard configuration. An optional upgrade allows 5 and 10Hz raw measurement data via either of the two serial ports.

The PVT (Position, Velocity, & Time) data is output at up to 1Hz in the standard configuration. An optional upgrade allows 5 and 10Hz position updates for highly dynamic applications.

- **GPS Performance**

The C-Nav1010 utilizes a precision GPS engine. The engine’s industry-leading receiver sensitivity provides more than 50% signal to noise ratio advantage over competing technologies. This results in improved real time positioning, proven through independent tests, when facing various multipath environments.

- **Rugged Design**

Units have been tested to conform to MIL-STD-810F for low pressure, solar radiation, rain, humidity, salt-fog, sand, and dust. The rugged design of the C-Nav1010 system components provides protection against the harsh conditions common to offshore and marine environments.

- **Accuracy**

The system provides <50cm position accuracy (post-convergence period) when C-Nav Corrections Service signals on the WAAS grid are used, <1m off the WAAS grid.

System accuracy with WAAS, EGNOS, MSAS, or GAGAN signals is subject to the quality and update rates of these publicly operated signals. Refer to *Related Standards/Publicly Operated SBAS Signals* for contact information regarding the organizations that implement the RTCA/DO-229D standard.

The system provides <1m position accuracy, when WAAS, EGNOS, MSAS, or GAGAN (RTCA/DO-229D compliant) SBAS correction signals are used.

The system provides <1m position accuracy, when DGPS code correction signals are used.

Chapter 2 Interfacing

This chapter details the C-Nav1010 GPS sensor connectors, LED display, appropriate sources of electrical power, and how to interface the communication ports.

Electrical Power

A rear panel 9-pin Positronic male connector provides electrical power to the C-Nav1010. Pin assignments are given below in *Figure 3.*

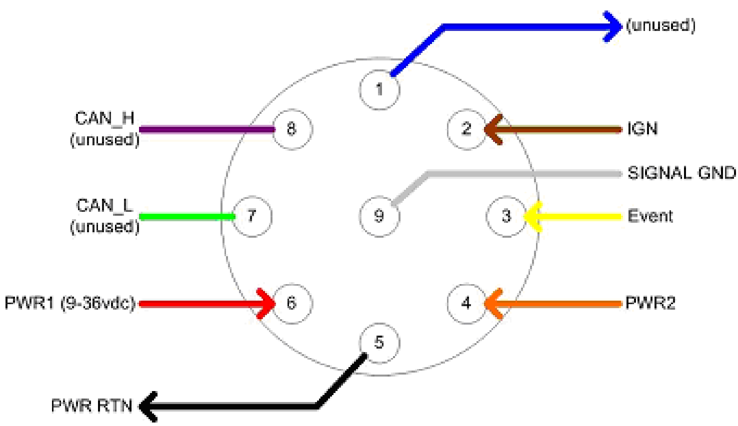


***Figure 3**: Power Port C Pin Assignments (Male Pin View)*

P/N: NAV94-310262-3010LF is a 10ft (3m) unterminated power cable fitted with a Positronic plug type, used to connect directly to a DC source. The wiring color code and pin assignments are labeled on the cable assembly and provided below.

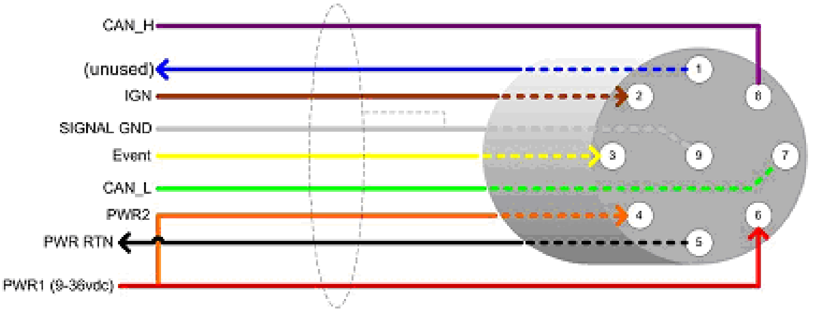


Figure 4: *DC Power Cable Pin Assignments*

(Female Pin View)

The GPS sensor is protected from reverse polarity with an inline diode. It will operate on any DC voltage between 9 and 36 VDC, 5 watts (maximum).

Voltages less than 9VDC will turn the unit off. To turn the unit on, power must be in the 9-36 VDC range. Press and hold the I/O switch in for more than 3 seconds.

Voltages in excess of 36VDC will damage the unit. The power supply must be well conditioned with surge protection. Vehicular electrical systems which create voltage spikes in excess of 36VDC will benefit from providing power protection during vehicle engine power-up. This can be accomplished through a relay power-on sequence and/or power conditioning (such as a DC to DC converter). Do not connect equipment directly to the vehicles battery without in-line protection (such as a DC to DC converter).

Functionality Rules: Interaction of front panel On/Off switch and Ignition Pin

If the unit is powered off from the front panel On/Off switch (see *Figure 7*):

Applying +7VDC or greater to the Ignition pin (see *Figure 3*) turns the unit on

Removing power from the Ignition pin turns the unit off

If the unit is turned on from the front panel On/Off switch, the Ignition pin is over-ridden and will not function.

If the unit is turned off from the Ignition pin, the front panel On/Off switch is over-ridden and will not function.

If the unit is turned on from the Ignition pin and the user wishes to use the On/Off switch for future on/off procedures, the unit must be turned off from the front panel On/Off switch.

Communication Ports

The C-Nav1010 provides two 9-pin female Positronic connector communication ports labeled Port A and Port B located at the back of the sensor, as shown in *Figure 8*. Each conforms to the EIA RS-232 standard with data rates from 4.8 to 115.2kbps. The connector pin-outs are described in *Table 3*. The supplied interface data cable (P/N: NAV94-310260-3006LF) is constructed as described in *Figure 5*.

The C-Nav1010 is configured as a DCE device. Laptop and desktop computers are configured as DTE devices, therefore a straight-through cable provides proper connectivity (PC TXD pin 2 connects to C-Nav1010 RXD pin 2).

Refer to *Table 4* for Acceptable RS-232 Cable Lengths.

***Table 3**: Port A and Port B Serial Cable Pin-Outs*

Positronic Pins	Signal Nomenclature [DCE w/respect to DB9]		DB9S Pins
	Port A	Port B	
1	Not connected	Not connected	-
2	Not connected	Not connected	-
3	Not connected	RD+ RS-422	8
4	RXD RS-232	RXD RS-232 RD- RS-422	3
5	TXD RS-232	TXD RS-232 TD- RS-422	2
6	Not connected	TD+ RS-422	7
7	Not connected	Not connected	-
8	Not connected	Not connected	-
9	GND	GND	5

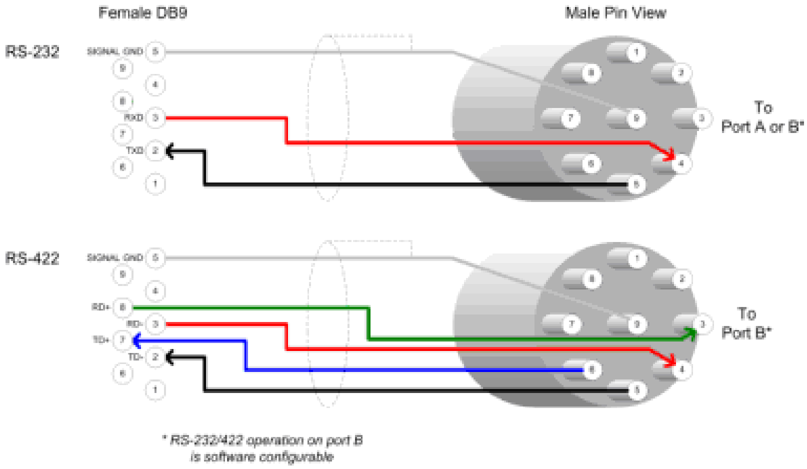


***Figure 5**: C-Nav Serial Cable Pin Assignment*

***Figure 6**: C-Nav Serial Cable*

(P/N: NAV94-310260-3006LF)

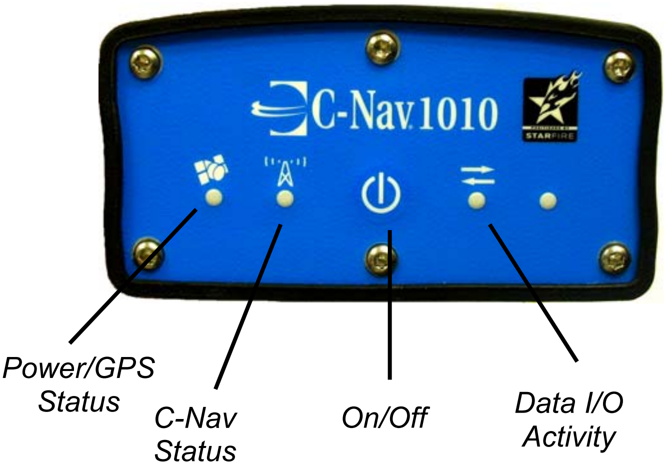


Figure 7: C-Nav1010 Front View

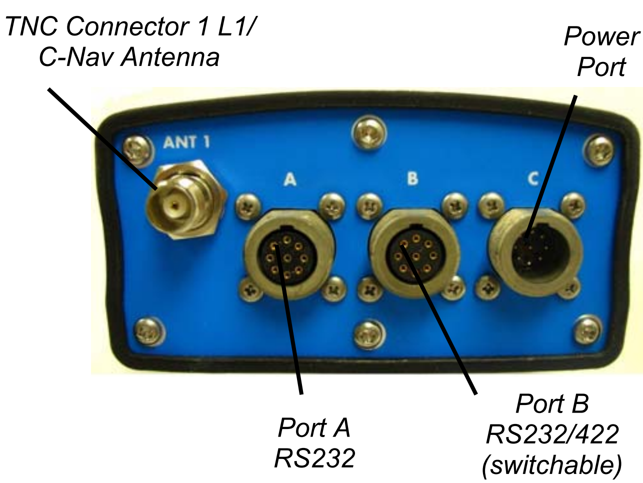


Figure 8: C-Nav1010M Back View

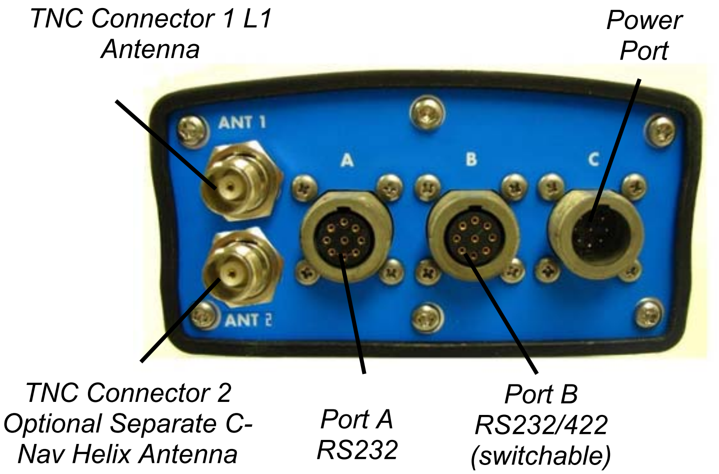


***Figure 9**: C-Nav1010R Back View*

***Table 4**: Acceptable RS-232 Cable Lengths*

Maximum Data Rate (bps)	Maximum Length
2,400 (2.4K)	120m (400ft)
4,800 (4.8K)	60m (200ft)
9,600 (9.6K)	30m (100ft)
19,200 (19.2K)	15m (50ft)
38,400 (38.4K)	7.5m (25ft)
57,600 (57.6K)	5.0m (16ft)
115,200 (115.2K)	2.5m (8ft)

Indicator Panel

GPS C-Nav Service On/Off Data

***Figure 10**: C-Nav1010 Indicator Panel*

The indicator panel provides a quick status view of the GPS navigation/operating mode, C-Nav Corrections Service signal strength, and the Data I/O, respectively. Each set of indicators has three LEDs. To power the unit on or off, depress the On/Off switch for more than 3 seconds. All LEDs illuminate for a period of 3-5 seconds during power-up of the GPS sensor.

Refer to the Functionality Rules on page *2-3* for details on powering the unit on/off

GPS LEDs

***Table 5**: GPS Light Indication*

Icon	Indicator	Status	Description
	***Power/GPS***	**Off**	Power off
		Red	Power on but not tracking
		Green Blinking	Acquiring GPS satellites (no nav 2D/3D fix yet)
		Green	Tracking GPS satellites (nav fix)

The GPS LEDs blink at the PVT positioning rate (1, 5, or 10Hz)

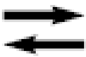
C-Nav Corrections Service Signal Link LEDs

***Table 6**: C-Nav Link LED Indication (Default)*

Icon	Indicator	Status	Description
	***C-Nav Link***	**Red**	No C-Nav signal
		Red Blinking	No C-Nav License
		Green Blinking	Acquiring C-Nav signal
		Green	Tracking C-Nav signal

Data I/O Active LEDs

***Table 7**: Data I/O Active Light Indication*

Icon	Indicator	Status	Description
	***Data***	**Red**	No data output
		Green Blinking	Data I/O active

Chapter 3 Installation

This chapter provides guidance on hardware installation for optimum performance.

Prior to commencing any installation, discuss proposed mounting locations/methods and cable routes with the vessel chief engineer or master to ensure that all parties are aware of the work to be done and the risks involved.

Always wear appropriate protective equipment, including a certified fall arrestor harness and hardhat when working at heights to prevent injury to personnel, or death. Prior to commencing any work on the mast, ensure that all radar systems are switched off and isolated.

Standard Antenna

Antenna placement is critical to good system performance. It is necessary to mount the antenna as high on the mast as possible in order to avoid antenna shading by surrounding structures.

***Figure 11**: Standard GPS/L-band Antenna*

Antenna Location

When choosing an antenna location, consider the following:

- ✓ Locate the antenna as high on the mast as possible, where it has a clear view of the sky, to an elevation angle of 7º if possible. Obstructions below 15º elevation generally are not a problem, though this is dependent on satellite availability for the local region.
- ✓ Avoid placing the antenna where more than 90º azimuth of the sky is obstructed. When more than 90º of azimuth is shaded, it is often still possible for the receiver to navigate, however, poor satellite geometry (due to satellite shading) will provide poor positioning results.
- ✓ Avoid placing the antenna on or near metal or other electrically reflective surfaces.
- ✓ Do not paint the antenna enclosure with a metallic-based paint.
- ✓ Secure the antenna to the mast firmly to minimize movement from wind and vibration which can affect the performance of the C-Nav1010 system.
- ✓ Avoid placing the antenna near electrical motors (generators, air conditioners, compressors, etc.) or other sources of interference such as radar systems, satcom domes, HF antennas or whip antennas.
- ✓ Do not place the antenna too close to other active antennas. The wavelength of L1 is 0.19m. The minimum acceptable separation between antennas is 1m (39 in), which provides 6dB of isolation. For 10dB of isolation, separate the GPS antennas by 2.5m (8ft), and for 13dB of

isolation (recommended) separate the antennas by 5m (16ft).

- ✓ Active antennas (those with LNA's or amplifiers) create an electrical field around the antenna. These radiated emissions can interfere with other nearby antennas. Multiple GPS antennas in close proximity to each other can create multipath and oscillations between the antennas. These add to position error or the inability to process the satellite signals
- ✓ A clear line of sight between the antenna and the local INMARSAT satellite is required to track the C-Nav Corrections Service signal. INMARSAT satellites are geo-synchronized 35,786kms above the Equator, currently at Longitudes: 142° West, 97.65° West, 15.5° West, 025° East, 109° East, and 143.5° East.
- ✓ Most antennas have better gain when the satellite is high in elevation. Expect tracking performance to fade as the satellite lowers in elevation. It is not unusual to see 10dB difference in antenna gain (which translates into signal strength) throughout the entire elevation tracking path.
- ✓ Use satellite prediction software with a recent satellite almanac to assess the impact on satellite visibility at your location. An L-band Communication Satellite Locator tool is available on C-Nav's website to aid in determining potential obstructions to the C-Nav Corrections Service Signal: *www.cnavgnss.com/calculator*

Both the GPS antenna port (ANT 1) and the C-Nav Corrections Service antenna port (ANT 2 - C-Nav1010R only) provide 5.0VDC, 150mA. Do not disconnect the antenna when the GPS unit is powered on.

Antenna Installation

1. Once the antenna location has been determined based on the previously mentioned criteria, mount the antenna onto the antenna mounting pole. This should be done on deck prior to climbing the mast as mounting the antenna aloft poses potential risks to personnel and equipment due to possible dropped object hazards.
2. Install the antenna with the antenna mounting pole in the predetermined location. The pipe can either be welded to the mast for a more permanent installation, or secured using stainless steel hose clamps.
3. Use a level to ensure that the antenna is mounted vertically.

L-band Antennas (C-Nav1010R Only)

The separate L-band antennas for the C-Nav1010R are used in high latitude applications and most frequently on marine vessels. These are active antennas, meaning they have built-in LNA. Therefore, these antennas should have good isolation from other near-frequency antennae. The best practice is to follow the same precautions as the standard GPS antennas.

***Figure 12**: High Latitude L-band Antennae*

On platforms with many antenna systems, it is better to locate the standard GPS antenna closer to the wheelhouse, but out of the radar or satcom beam path and the L-band antenna high on the mast.

Applications at high latitudes without the L-band antenna should mount the GPS antenna high on the mast, with the same considerations for beam path avoidance and cable loss limitations. Refer to *Table 8* for acceptable cable lengths.

Refer to *Appendix B* for Standard and L-band antenna specifications.

Coaxial Cable

Proper installation of coaxial cables is important to ensure successful communication between the antenna and the GPS Sensor. Antenna cable can degrade signal quality if incorrectly installed.

Cable Route

- ✓ When choosing a cable route for coaxial cable, consider the following:
- ✓ Ensure that the cable route is free of and sharp edges or places where the cable could kink, stretch, distort or become damaged in any way
- ✓ Determine the manufacturers specifications for the coaxial cable in use. This should include: impedance, diameter, attenuation in dB/100ft and dB/100m at 1575MHz, velocity of propagation and the minimum bend radius of the cable.
- ✓ Ensure there is sufficient space at the cable entry point to the bulkhead as to not damage the connector during installation.
- ✓ Measure the length of the cable route and refer to *Table 8* for acceptable cable lengths in relation to attenuation loss at the frequencies in use. For best performance, do not allow more than 7dB of cable loss between the antenna and the receiver, though the C-Nav1010 system may tolerate up to 10dB of cable loss with minimal performance. Lower elevation satellite tracking suffers the most with more than 7dB insertion loss.
- ✓ In-line amplifiers suitable for all GPS frequencies may be used to increase the length of the antenna cable, but care should be exercised that tracking performance is not degraded due to multiple connections, noise from the amplifier, and possible ingress of moisture and dust to the in-line amplifier. In-line amplifier or splitter devices must pass DC power from the receiver to the antenna, or source the appropriate voltage and current to the antenna (see

Appendix B). In-line amplifiers may also over-saturate the receiver front-end if improperly used.

- ✓ Avoid running coaxial cable across, or adjacent to power cables and high power RF cables. In instances where this cannot be avoided, attempt to cross cables at 90° angles in an effort to reduce cross coupling of RF signals.

Coaxial Cable Installation

1. Prior to connecting the coaxial antenna cable to the antenna, ensure that all connections are free of dirt and other debris. Apply silicone grease to the connector threads and wipe off any excess, ensure not to get any lubricant on the contact. Connect the coaxial cable and tighten firmly. Wrap the connection with self-amalgamating tape or another weather sealant like Coax-seal® to prevent water ingress.

2. Slacken the coaxial cable and tape to the antenna-mounting pole. This will prevent any undue strain on the cable connector and antenna.

3. With the cable connected to the antenna, run the cable down the mast, securing with zip ties every 3 or 4 feet.

4. Carefully lay the cable along the chosen route to further detect any potential kinks, bends or spots where the cable may become damaged.

5. Secure the cable along the cable route with tape or zip ties and place a label at the GPS sensor end of the cable for identification purposes.

6. Connect the coaxial cable to the female TNC connector on the GPS sensor labeled ANT 1. Ensure that any slack in the cable is neatly stowed and that the minimum bend radius is not exceed during this process.

7. *C-Nav1010R only*. If using the L-band antenna at high latitudes, connect the coaxial cable to the female TNC connecter on the GPS sensor labeled ANT 2 (See *Figure 9).*

Table 8*: Acceptable Cable Lengths*

Cable Type	Atten. (dB) per 100 Ft.	Cable Length in Feet	Loss in dB	Atten. (dB) per 100 m	Cable Length in Meters	Loss in dB
RG-58C	19.605	36.00	7.06	64.32	11.00	7.08
RG-142	16.494	43.00	7.09	54.12	13.00	7.04
RG-213	9.564	74.00	7.08	31.38	22.50	7.06
RG-223	17.224	41.00	7.06	56.51	12.50	7.06
LMR600	3.407	207.00	7.05	11.18	63.00	7.04
LMR400	5.262	133.00	7.00	17.26	41.00	7.08
LMR240	10.127	70.00	7.09	33.23	21.00	6.98
LMR195	14.902	47.00	7.00	48.89	14.00	6.85

Lightning Protection

Where the GPS antenna is exposed to sources of electromagnetic discharge such as lightning, install a properly grounded in-line electrical surge suppressor between the GPS sensor and antenna. Install protective devices in compliance with local regulatory codes and practices. Protective devices must pass DC power from the receiver to the antenna.

GPS Sensor

The C-Nav1010 GPS sensor is best installed using the mounting brackets provided.

GPS Sensor Location

- ✓ When choosing a location for GPS Sensor installation, consider the following:
- ✓ Avoid placing the sensor in direct sunlight, places with inadequate ventilation, or where it might be subject to excessive dust.
- ✓ Ensure the sensor is mounted securely to a flat surface in an area with little vibration. Shock isolators suitable for 1.8kg (4lbs) may be necessary for environments with high vibration.
- ✓ Do not place the sensor in a confined space or where it may be exposed to excessive heat, moisture, or humidity.
- ✓ Install the sensor in a location with easy access to both the front and back panels.

⚠ There are no user serviceable parts inside the C-Nav1010 GPS sensor. Removing the screws that secure the front end and rear end plates will void the equipment warranty.

Block Diagrams

The C-Nav1010 has three user configurable physical communications ports (two external and one internal) and several logical communications ports. Please refer to the block diagrams below.

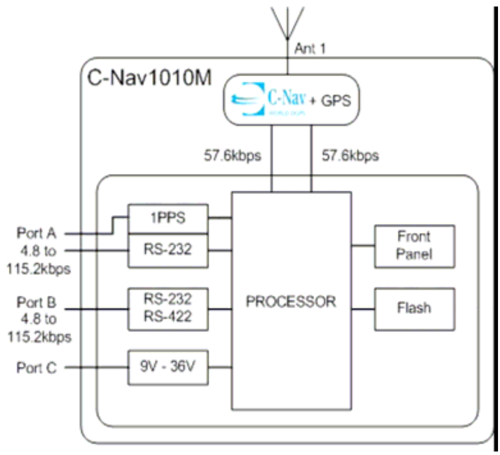


Figure 13: *C-Nav1010M Block Diagram*

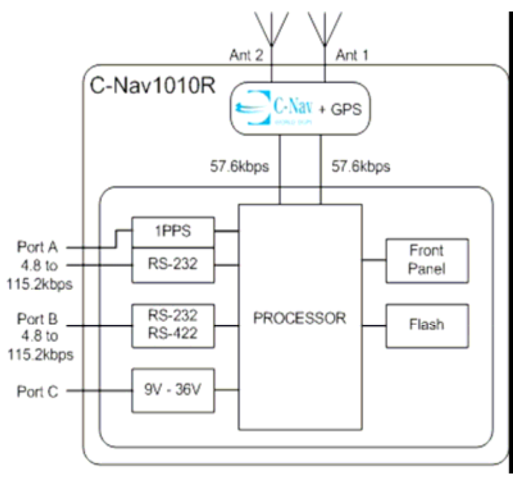


Figure 14: *C-Nav1010R Block Diagram*

Communication Port Connectivity

There is no default control port on the receiver. Connect the supplied Positronic 9-Pin connector of the serial cable (P/N: NAV94-310260-3006LF) to Port A or Port B of the C-Nav1010. Connect the DB9 end to the control device.

Figure 15 shows a common configuration with the control device connected to Port A and an auxiliary device connected to Port B for data logging. Some devices may require an adapter. The receiver is configured as a DCE device.

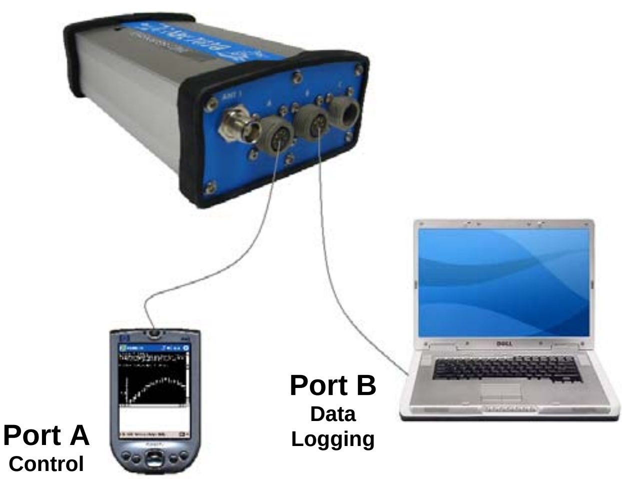


***Figure 15**: Possible Com Port Setup*

Figure 16 shows an optional configuration with the control device connected to Port A and an RS-232/RS-422 cable with a splitter to Port B for NMEA data output and RTCM input, respectively.

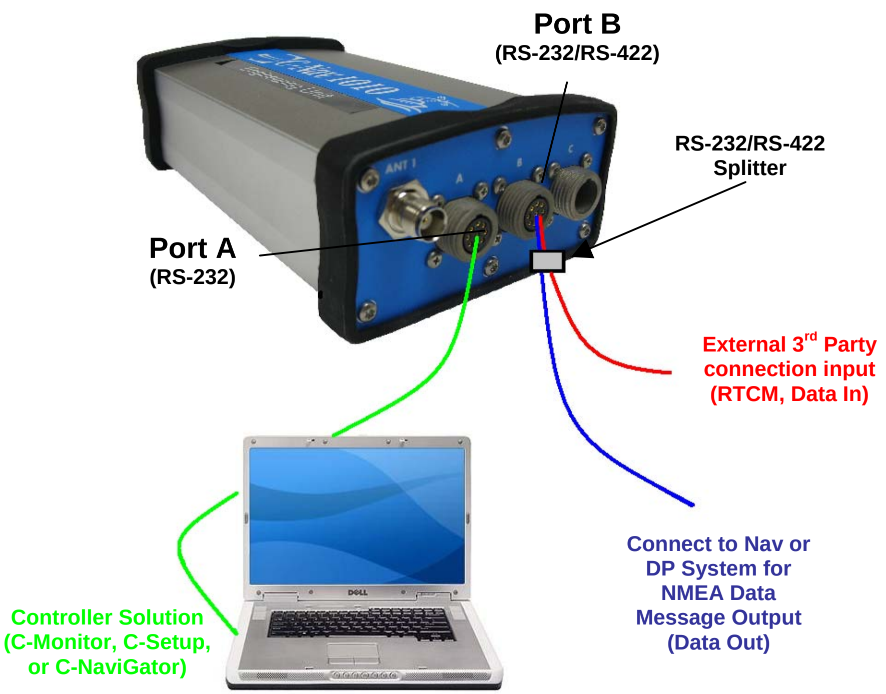


Figure 16*: Optional Com Port Setup with RS-232/422 Splitter*

For GPS sensor specifications and dimensions, refer to *Appendix A*

Chapter 4 Configuration

The C-Nav1010 has a rich interface and detailed control language, allowing each unit to be individually tailored to a specific application.

There are essentially 2 methods available to configure and control the C-Nav1010:

- ✓ C-Setup, C-Monitor, C-NaviGator – These programs/CDU's are C-Nav developed utilities designed to configure and view many of the C-Nav1010 functions. In addition to setup capabilities, C-Nav proprietary software can capture and log data, upload new software and licenses to the internal processors, and query and display various receiver performance functions.

- ✓ 3rd party controller – Some manufacturers have already integrated C-Nav's control features in their bundled hardware and software solution kits in a variety of applications including GIS, Machine Control, Aerial Photogrammetry, Land & Oceanographic Survey, Agriculture, and Military products. Information on these applications is available from the C-Nav website and customer service.

Port Configuration

There is no default control port on the receiver. When either port is connected to control software (such as C-Setup), that port becomes the control port.

Port A

- ✓ Configuration – Control or Data Port
- ✓ Rate – 57.6Kbps

This port is normally used to input and output proprietary messages used for navigation and receiver setup. *Table 9* describes the default messages needed to best initiate surveying with minimal effort.

The user has full control over the utilized message types and their associated rates via C-Setup, C-Monitor, C-NaviGator or a third party software/utility.

Port B

- ✓ Configuration – Control or Data Port
- ✓ Rate – 57.6Kbps

This port is normally used to output data to other devices or machines that can make immediate use of the precise positioning data available from the C-Nav1010. The data port outputs NCT Binary Messages and NMEA Messages, and when applying external DGPS corrections, also serves as the DGPS correction input port.

Factory Default Output Messages

NCT Binary Messages

***Table 9**: Factory Default NCT Binary Messages*

Msg	Rate	Description
81	On Change	Ephemeris
86	On Change	Channel Status
A0	On Change	Alert Message
AE	600 Seconds	Identification Block
B0	On Change	Raw Measurement Data
B1	On Change	PVT Solution

The term “On Change” indicates that the C-Nav1010 will output the specified message only when the information in the message changes. On occasion, there may be an epoch without a message block output.

Message Descriptions

The following message descriptions are fully defined in the C-Nav1010 Technical Reference Manual (see *Related Documents*) and in *Appendix D*.

- ✓ 81 Packed Ephemeris:
  Individual satellite tracking information including: GPS Week number of collected ephemeris, GPS Time of week [in seconds] of collected ephemeris, IODC, and sub-frame 1, 2, and 3 data.
- ✓ 86 Channel Status:
  Receiver channel status information containing: the GPS week, GPS Time of Week, number of

satellites viewed/tracked, PDOP, tracked satellite identity, satellite elevation and azimuth, C/No for the L1 signals, and correction age for each satellite.

- ✓ A0 Alert Text Message:
  Details message receipt and processing.
- ✓ AE Identification Block:
  Details the receiver software versions (GPS Engine, and Processor) and digital serial numbers.
- ✓ B0 Raw Measurement Data:
  Raw Measurement Data Block containing: the GPS Week, GPS Time of Week, Status, Channel Status, C/A Pseudorange, and L1 Phase. This data stream is repeated for each individual tracked satellite.
- ✓ B1 PVT (Position, Velocity, and Time):
  Provides GPS Week number, satellites used, latitude, longitude, navigation mode, and DOP information.

***Table 10**: Factory Default NMEA Messages*

Msg	Rate	Description
GGA	On Change	GPS Fix Data
VTG	On Change	Course Over Ground & Ground Speed

Message Descriptions

- ✓ GGA GPS Fix Data:
  (Time, position and fix related data)
- ✓ VTG Course Over Ground & Ground Speed:
  (The actual course and speed relative to the ground)

3rd Party Controller Configuration Settings

Please refer to the third party controller solution manual/users guide if the C-Nav1010 GPS sensor is part of an integrated solution.

Chapter 5 Safety Instructions

The C-Nav1010 GPS sensor is designed for precise navigation and positioning using the Global Positioning System. Users must be familiar with the use of portable GPS equipment, the limitations thereof, and these safety instructions prior to use of this equipment.

Transport

Always carry C-Nav equipment in either the original packing material or packaging which provides protection to the receiver and antenna against shock and vibration.

Utilize all original packaging when transporting via rail, ship, or air.

Maintenance

C-Nav equipment may be cleaned using a new lint free cloth moistened with pure alcohol.

Connectors must be inspected, and if necessary cleaned before use. Always use the provided connector protective caps to minimize moisture and dirt ingress.

Inspect cables regularly for kinks and cuts as these may cause interference and equipment failure.

Damp equipment must be dried at a temperature less than 40°C (104°F), but greater than 5°C (41°F) at the earliest opportunity.

External Power Source

The C-Nav1010 is supplied with an external power cable (P/N: NAV94-310262-3010LF). This must be connected to the chosen external power solution in accordance with *Chapter 2* Interfacing - Electrical Power. It is important that the external power source allow sufficient current draw for proper operation.

Insufficient supplied current will cause damage to the external power source.

If the chosen external power source is a disposable battery, please dispose of the battery in accordance with local regulations.

Safety First

The owner of this equipment must ensure that all users are properly trained prior to using the equipment and are aware of the potential hazards and how to avoid them.

Other manufacturer’s equipment must be used in accordance with the safety instructions issued by that manufacturer. This includes other manufacturer’s equipment that may be attached to C-Nav manufactured equipment.

Always use the equipment in accordance with local regulatory practices for safety and health at work.

There are no user serviceable parts inside the C-Nav1010 GPS sensor. Accessing the inside of the equipment will void the equipment warranty.

Take care to ensure the C-Nav1010 does not come into contact with electrical power installations, the unit is securely fastened and there is protection against electromagnetic discharge in accordance with local regulations.

Appendix A GPS Sensor Specifications

The technical specifications of this unit are detailed below. C-Nav is constantly improving and updating our technology. For the latest technical specifications for all products go to: *www.cnavgnss.com*

These GPS sensors are fitted with an internal Lithium coin cell battery used to maintain GPS time when power is removed from the unit. This allows faster satellite acquisition upon unit power up. The cell has been designed to meet over 10 years of service life before requiring replacement at a C-Nav approved maintenance facility.

Features

- ✓ "All-in-view" tracking on 16 channels (14 L1 GPS + 2 SBAS)
- ✓ Global half-meter level accuracy using the C-Nav Corrections Service
- ✓ Fully automatic acquisition of C-Nav Corrections Service Signals
- ✓ Two seperate SBAS channels, RTCA/DO-229D compliant (WAAS, EGNOS, MSAS, GAGAN)
- ✓ L1 C/A code with carrier phase smoothing
- ✓ User programmable measurement, output and navigation data rates
- ✓ Output format NMEA 0183 v3.1 or C-Nav proprietary binary
- ✓ Certification: FCC Part 15 Class B, CE

Time-To-First-Fix

Cold Start Satellite Acquisition	< 45 Seconds (typical/without Almanac)
Satellite Reacquisition	< 1 second outage time; immediate reacquisition < 30 seconds software, typical; with outage time < 65 seconds > 65 seconds outage time requires full acquisition process

Dynamics

Acceleration:	4g
Speed:	< 1000knots (515 m/s*)
Altitude:	< 60,000 ft* (18.3 km)

*Restricted by export laws

User Programmable Output Rates

PVT	1Hz Standard 5 &10Hz Optional
Raw data	1Hz Standard 5 & 10Hz Optional

Data Latency

PVT	< 100 ms at all rates
Raw data	< 100 ms at all rates
Accuracy:	50ns (Relative; User Configurable)

Measurement Performance

Real-time C-Nav Accuracy	
Position (H): Position (V): Velocity: W/O WAAS IONO	<50 cm <1 m 0.03 m/s <1m H; <1.5m V
Real-time WAAS, ENGOS, MSAS, GAGAN SBAS Accuracy	
Position (H): Position (V): Velocity:	<1 m <2 m 0.03 m/s
RTCM Code Differential GPS <200km (RMS)	
Position (H): Position (V): Velocity:	<1 m <2 m 0.03 m/s
Pseudorange Measurement Precision (RMS)	
Raw C/A code: Raw carrier phase noise:	90cm 5 mm

LED Display Functions (Default)

GPS	Position Quality
Link	C-Nav Signal Strength
Data I/O Active	

Connector Assignments

Port A	RS-232 serial port, from 4800 bps to 115.2 kbps
Port B	RS-232/RS-422 serial port, from 4800 bps to 115.2 kbps
Port C	Power port, from 9VDC to 36VDC

Input/Output Data Messages

NCT Proprietary Data	PVT, Raw Measurement Satellite Messages Nav Quality Receiver Commands PNCTSET
NMEA-0183 Messages (Output Only)	ALM, GBS, GGA, GLL, GRS, GSA, GST, GSV, RMC, VTG, and ZDA
Code Corrections	RTCM 1 or 9; 3 WAAS, EGNOS, MSAS, GAGAN C-Nav Corrections Service

See *Related Standards* at the front of this manual for information on the various data formats

Satellite Based Augmentation System Signals

RTCA/DO-229D Standard (WAAS, EGNOS, MSAS, GAGAN)
C-Nav Corrections Service

Physical and Environmental

Size (L x W x H): w/o Bracket	< 8.3 x 4.7 x 2.5(in) (211 x 119.4 x 63.5) mm
Size (L x W x H): with Bracket	< 8.3 x 6.55 x 2.56(in) (211 x 166 x 65) mm
Weight:	1.7lbs (0.77 kg)
External Power: Input Voltage: Consumption:	9 VDC to 36 VDC <5 W
Connectors: I/O Ports: DC Power: GPS/L-band Antenna: L-band Antenna:	2 x 9 pin Circular 1 x 9 pin Circular TNC-F TNC-F (C-Nav1010R Only)
Antenna Power: ANT 1: ANT 2 (C-Nav 1010R Only):	5.0 VDC, 150mA 5.0 VDC, 150mA
Temperature (ambient) Operating Storage:	-30º to +70º C (-22º to +158º F) -40º to +85º C (-40º to +185º F)
Humidity:	95% non-condensing

Dust	MIL-STD-810F, Method 510.4, Procedure I (Dust)6h 1750 +/- 175ft/min blowing dust at 10.6 +/- 7g/m³ at 25°C and 70°C.
Sand	MIL-STD-810F, Method 510.4, Procedure 2; 90 mins 18-29m/s blowing sand at 2.2 +/- 0.5g/m³ from front and back.
Precipitation	MIL-STD-810F, Method 506.4, Procedure I; 30min of 40mph 0.5mm-4.5mm droplets front and back.

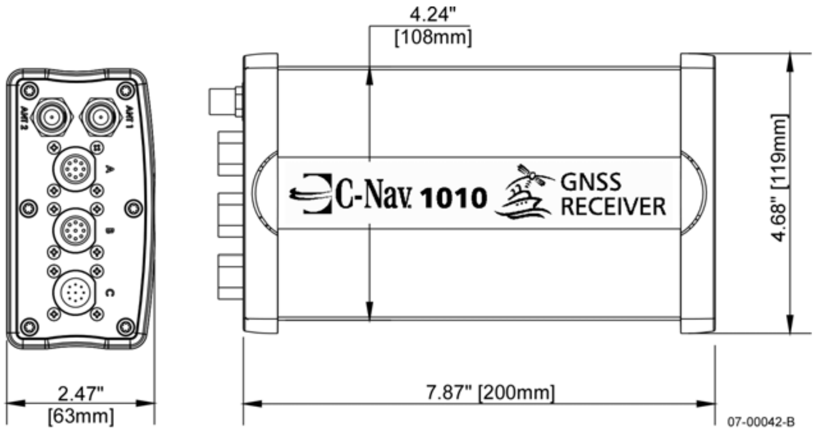


***Figure A1**: C-Nav1010 Base Plate Dimensions Without Mounting Brackets*

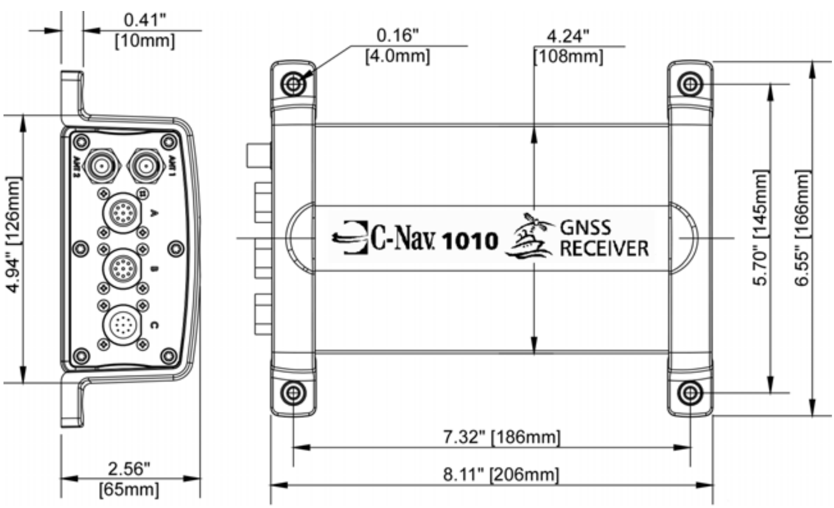


***Figure A2**: C-Nav1010 Base Plate Dimensions With Mounting Brackets*

Appendix B Antenna Specifications

Standard Antenna

Frequency	1525-1660 MHz GPS L1 plus C-Nav Corrections Service
Polarization	Right Hand Circular (RHCP)
Pre–Amplifier	35dB gain (+/-1.2dB)
Noise Figure	<2.1dB
Filter Rejection	9dB @ 1690MHz 21dB @ 1626MHz 38dB @ 1660MHz
Impedance	50 Ohms
VSWR / RL	≤ 2.0:1 / 9.54dB min.
Band Rejection	20dB @ 250MHz
RF Power Handling	+30dBm (1 W)
Input Voltage	2.5 – 24 VDC
Power Consumption	0.2W 39mA ±10mA @ 5VDC
Cable Connector	TNC Female
Operating Temp	-55°C to +85°C
Altitude	70,000ft; 21,336m
Finish	Skydrol resistant polyurethane Enamel with nickel plated base
Material	6061-T6 Aluminum alloy base composite radome, impact, abrasion, UV, solvent, skydrol resistant, and fire retardant
Weight	397g (14oz)
Vibration	>30g's

Designed to	FAA TSO-C144, DO-160D, D0-228, MIL-C-5541, MIL-E-5400, MIL-I-45208A, MIL-STD-810, AND SAE J1455
Mount Dimensions	1”-14 thread Depth of 1.25”; 32mm

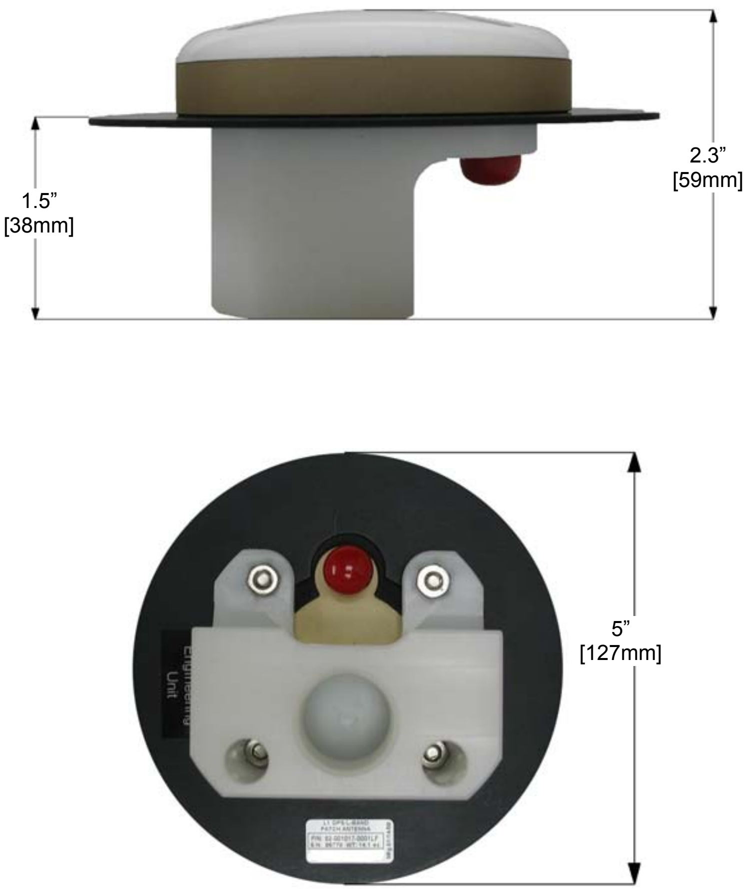


***Figure B1**: Antenna Dimensions*

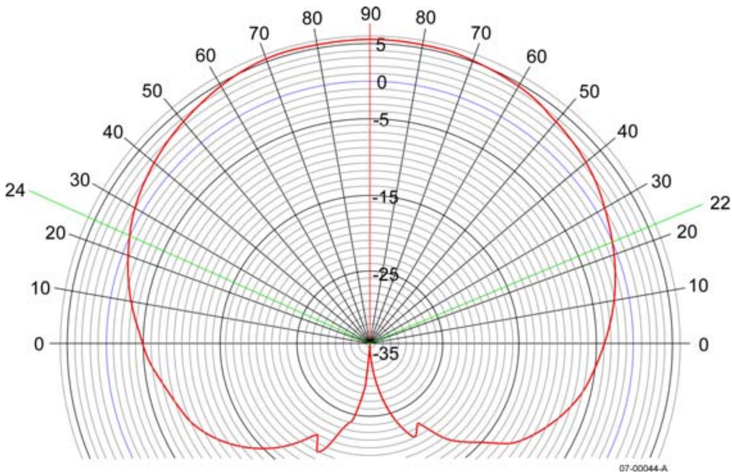


***Figure B2**: Radiation Pattern*

Optimal antenna performance is realized at elevations greater than 30º.

There is a 10dB variation between 0º and 90º elevation (factor 10x); therefore, lower elevation satellites are always more difficult to track.

There is a 5dB variation between ~35º and 0º elevation (factor >3x)

L-band Antennae *(C-Nav1010R Only)*

Part Number	P/N: NAV82-001018-0001LF
Frequency	1525-1575 MHz INMARSAT C-Nav
Polarization	Right Hand Circular (RHCP)
Pre–Amplifier	34dB gain min.
Noise Figure	2.9dB
Impedance	50 Ohms
Input Voltage	2.5 to 24 VDC
Power Consumption	0.3W typical 60mA ±10mA @ 5.0VDC
Connector	TNC Female
Operating Temp	-55°C to +85°C
Finish	Skydrol resistant polyurethane Enamel base Iriditeper MIL-C-5541
Material	6061-T6 Aluminum alloy base composite radome, impact, abrasion, UV, solvent, skydrol resistant, and fire retardant
Weight	5.2oz [146g]
Vibration	>30g's
Designed to	FAA TSO-C144, DO-160D, D0-228, MIL-C-5541, MIL-I-45208A, MIL-STD-810, AND SAE J1455
Wind loading	135 MPH

Part Number	NAV82-001003-0001LF
Frequency	1525-1585 MHz INMARSAT C-Nav Corrections Service
Polarization	Right Hand Circular (RHCP)
Pre–Amplifier	25dB gain min. (to coax end)
Noise Figure	1.0dB typical
Impedance	50 Ohms
Input Voltage	3.0 to 5.5 VDC
Power Consumption	0.3W typical 8.5mA ±10mA @ 3.6VDC
Cable Connector	TNC Female
Cable Length	3 meters
Operating Temp	-55°C to +85°C
Magnetic attachment shear strength	3Kg Typical
Direct attachment force pull	4Kg Typical
The quadrafilar antenna wind loading	200Km/hr.
Minimum break-over force (foliage brushing)	10Kgm

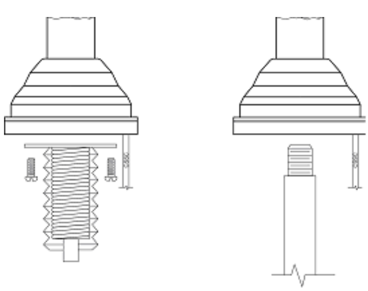
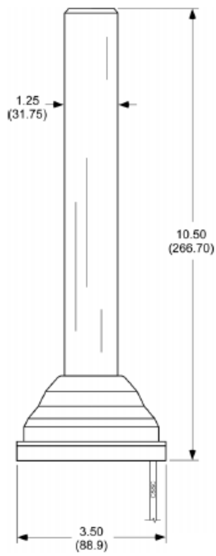


***Figure B3**: NAV-82-001003-0001LF Antenna Mounts*



(P/N: NAV82-001003-0001LF, <25°)

(P/N: NAV82-001018-0001LF, 45°-25°)

***Figure B4**: Antenna Dimensions (C-Nav1010R only, 45°-25° and <25° Antennas)*

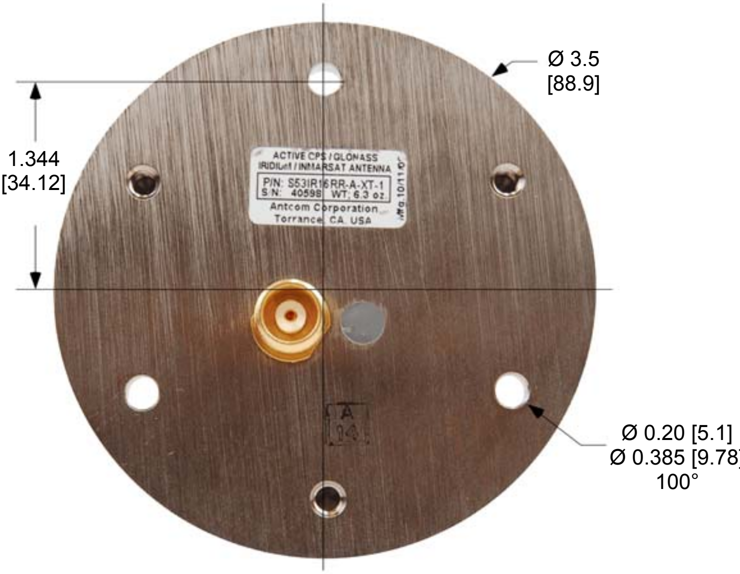


Figure B5*: NAV82-001018-0001LF Antenna Mount*

Figure B6*: Pipe Mount Adapter for L-band C-Nav1010R Antenna*

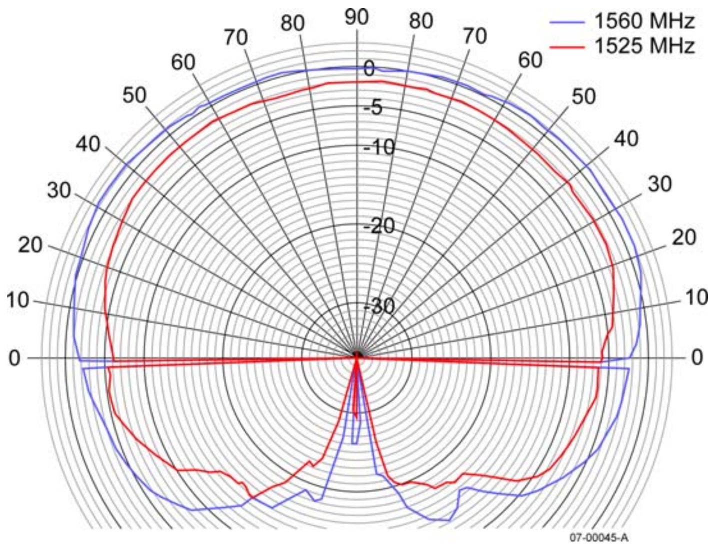


***Figure B7**: Radiation Pattern*

Optimal antenna performance is realized at elevations between 10º and 50º.

There is an 8dB variation between 40º and 90º elevation (factor 6.3x); therefore, higher elevation satellites are always more difficult to track.

There is a 3dB variation between 10º and 0º elevation (factor >2x)

Appendix C C-Nav Corrections Service

Description

The C-Nav Corrections Service Network is a global system for the distribution of SBAS corrections giving the user the ability to measure their position anywhere in the world with exceptional reliability and unprecedented accuracy of better than 50cm (19.7 inches; in this product). Because the SBAS corrections are broadcast via INMARSAT geo-stationary satellites, the user needs no local reference stations or post-processing to get this exceptional accuracy. Furthermore, the same accuracy is available virtually any where on the earth's surface on land or sea from 72°N to 72°S latitude, due to the worldwide coverage of these geostationary satellites.

Infrastructure

The system utilizes GNSS satellite systems, L-band communication satellites, and a worldwide network of reference stations to deliver real-time high precision positioning.

To provide this unique service, C-Nav has built a global network of multi-frequency reference stations, which constantly receive signals from GNSS satellites as they orbit the earth. Data from these reference stations is fed to two U.S.-based processing centers in Torrance, California and Moline, Illinois where they are processed to generate the differential corrections.

From the two processing centers, the correction data is fed via redundant and independent communication links to satellite uplink stations at Laurentides, Quebec, Canada; Perth, Australia; Burum, The Netherlands; Santa Paula, California; Auckland, New Zealand and Southbury, Connecticut for rebroadcast via the geostationary satellites.

The key to the accuracy and convenience of the C-Nav Corrections Service is the source of SBAS corrections. GNSS satellites transmit navigation data on multiple L-band frequencies. C-Nav reference stations are all equipped with geodetic-quality, multi-frequency receivers. These reference receivers decode GNSS signals and send precise, high quality, dual-frequency pseudorange and carrier phase measurements back to the processing centers together with the data messages, which all GNSS satellites broadcast.

At the processing centers, C-Nav's proprietary differential processing techniques are used to generate real time precise orbits and clock correction data for each satellite in the GNSS constellations. This proprietary Wide Area DGNSS (WADGNSS) algorithm is optimized for a multi-frequency system such as the C-

Nav Corrections Service in which multi-frequency ionospheric measurements are available at the reference receivers. It is the use of multi-frequency receivers at the reference stations together with the advanced processing algorithms, which makes the exceptional accuracy of the C-Nav Corrections Service possible.

Creating the corrections is just the first part. From our two processing centers, the differential corrections are then sent to the Land Earth Station (LES) for uplink to L-band communications satellites. The uplink sites for the network are equipped with C-Nav-built modulation equipment, which interfaces to the satellite system transmitter and uplinks the correction data stream to the satellite that broadcasts it over the coverage area. Each L-band satellite covers more than a third of the earth.

Users equipped with a C-Nav precision GNSS receiver actually have two receivers in a single package, a GNSS receiver and an L-band communications receiver, both designed by C-Nav for this system. The GNSS receiver tracks all the satellites in view and makes pseudorange measurements to the GNSS satellites. Simultaneously, the L-band receiver receives the correction messages broadcast via the L-band satellite. When the corrections are applied to the GNSS measurements, a position measurement of unprecedented real time accuracy is produced.

Reliability

The entire system meets or exceeds a target availability of 99.99%. To achieve this, every part of the infrastructure has a built-in back-up system.

All the reference stations are built with duplicate receivers, processors and communication interfaces, which switch automatically or in response to a remote control signal from the processing centers. The data

links from the reference stations use the Internet as the primary data link and are backed up by dedicated communications lines, but in fact the network is sufficiently dense that the reference stations effectively act as back up for each other. If one or several fail, the net effect on the correction accuracy is not impaired.

There are two continuously running processing centers, each receiving all of the reference site inputs and each with redundant communications links to the uplink LES. The LESs are equipped with two complete and continuously operating sets of uplink equipment arbitrated by an automatic fail over switch. Finally, a comprehensive team of support engineers maintains round the clock monitoring and control of the system.

The network is a fully automated self-monitoring system. To ensure overall system integrity, an independent integrity monitor receiver, similar to a standard C-Nav user receiver, is installed at every reference station to monitor service quality. Data from these integrity monitors is sent to the two independent processing hubs in Torrance, California and Moline, Illinois. Through these integrity monitors the network is continuously checked for overall SBAS positioning accuracy, L-band signal strength, data integrity and other essential operational parameters.

How to Access the C-Nav Corrections Service

The C-Nav Corrections Service is a subscription service. The user pays a subscription, which licenses the use of the service for a predetermined period of time.

Subscriptions can be purchased for any predetermined period of time and are available via a C-Nav authorized representative, or by contacting C-Nav at: *cnav.support@cnavgnss.com*

An authorized subscription will provide an encrypted key, which is specific to the Serial Number of the C-Nav receiver to be authorized. This is entered into the receiver using the provided controller solution. Typically the initial license is preinstalled at the factory, and the user will install subsequent licenses.

When contacting C-Nav regarding subscription or deactivation of service, please have the following information available:

Company Name and Contact Information

PO/Reference No.

Vessel Name, Location and No. (if applicable)

Required Start/Stop Date or Period

Service Type (Land or Offshore/Activation or Deactivation)

Operational Region

Receiver Type

The only piece of equipment needed to access the C-Nav system is a C-Nav receiver. C-Nav offers a variety of receivers configured for different applications. Details of all the C-Nav receivers are available from a C-Nav authorized local representative or on the C-Nav website at: *www.cnavgnss.com/Products*

C-Nav receivers include a single-frequency GPS receiver and an L-band receiver integrated into a single unit to provide the exceptionally precise positioning capability of the C-Nav Corrections Service Network, anywhere, anytime.

C-Nav1010 GPS System - Subscription Activation Form

TO: C-Nav 730 East Kaliste Saloom Lafayette, Louisiana, 70508, USA **TEL:** +1 337 261 0660 **FAX:** +1 337 261 0192 **E-MAIL:** cnav.support@cnavgps.com	**FROM:** **TEL:** **FAX:** **MOB:** **E-MAIL:** **CC:**	**C&C Job No.**

Please check items and fill out all information and dates for Requested Service

Vessel	**Name:**	**Number:**	**Location:**

ID	**Company Name:**	**PO/Reference No.:**	**Contact Manager:**

RECEIVER	**GPS**	**Firmware Version:**	**GPS Serial Number**					
	LBD	**Firmware Version:**	**L-Band Demodulator Serial Number**					

TYPE	❑ **Activate**	**Start:** *Month/Day/Year*	**Stop:** *Month/Day/Year* **Duration:** *No. Days*
		Service: ❑ Land Only ❑ Global Offshore	
		REGION ❑ Asia, Australia, China, South & Central America, Caribbean, Africa, Middle East ❑ Net 1 - *Americas(98W), Europe/Africa(25E), Asia/Pacific(109E)* ❑ Net 2 - *Americas(142W), Europe/Africa(15.5W), Asia/Pacific(143.5E)* ❑ All Others ❑ Net 1 - *Americas(98W), Europe/Africa(25E), Asia/Pacific(109E)* ❑ Net 2 - *Americas(142W), Europe/Africa(15.5W), Asia/Pacific(143.5E)*	
		PROJECT/SERVICE DESCRIPTION:	
	❑ **Deactivate**	**Stop:** *Month/Day/Year*	

Signature:	**Print Name:**	**Date:**

By requesting C-Nav GPS System Subscription Service activation, the user agrees to abide by the terms and conditions for the use and operation of the C-Nav GPS System and the GcGPS Subscription Service correction signals usage. C&C Technologies will provide a NEW Activation Code FILE on receipt of this signed facsimile request and having completed authorization and verification procedures, to the originator / requestor of this request form and also to the company operations management / department responsible for the account invoice payments.

Notes:

For online activation and deactivation, go to: http://www.cnavgnss.com/code

For a full-size PDF version of the C-Nav Subscription Form, refer to included Product CD.

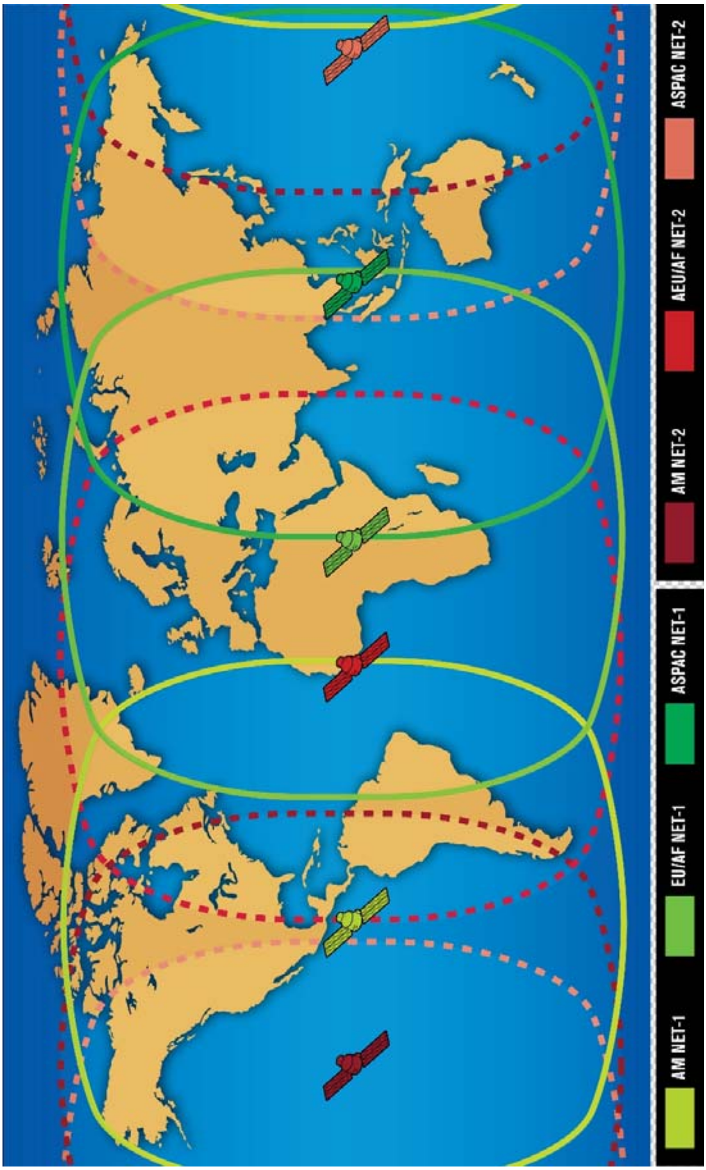


***Figure C1**: C-Nav Corrections Service Network*

Appendix D
NMEA Data Output Message Formats

$GPALM

This output message reports orbital data (almanac) for the specified GPS satellite, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPALM,total,message,prn,week,health,eccentricity,reftime,inclination,ascension, axis,perigee,node,anomaly,F0clock,F1clock*checksum	
Field#	Field Name	Description
F1	total	Total number of messages (01 to 32)
F2	message	Message number (01 to 32)
F3	PRN	GPS satellite PRN number (01 to 32)
F4	week	GPS week number (4 digits)
F5	health	SV health (ASCII hex, 2 bytes)
F6	eccentricity	Eccentricity (ASCII hex, 4 bytes)
F7	reftime	Almanac reference time (ASCII hex, 2 bytes)
F8	inclination	Inclination angle (ASCII hex, 4 bytes)
F9	ascension	Rate of right ascension (ASCII hex, 4 bytes)
F10	axis	Root of semi-major axis (ASCII hex, 2 bytes)
F11	perigee	Argument of perigee (ASCII hex, 6 bytes)
F12	node	Argument of perigee (ASCII hex, 6 bytes)
F13	anomaly	Mean anomaly (ACSII hex, 6 bytes)
F14	F0clock	F0 clock parameter (ASCII hex, 3 digits)
F15	F1clock	F1 clock parameter (ASCII hex, 3 digits)
F16		Checksum

Example:

*$GPALM,32,1,01,1423,00,35BF,7B,1F38,FD5B,A10D8B,78C23F,B7E3C6, 379706,080,001*36*

$GPGBS

This output message is used to support Receiver Autonomous Integrity Monitoring (RAIM), and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGBS,time,laterr,lonerr,alterr,prn,probability,estimate,bias*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	laterr	Expected error in latitude in meters
F3	lonerr	Expected error in longitude in meters
F4	alterr	Expected error in altitude in meters
F5	Prn	PRN of most likely failed satellite, GPS (01 to 32), WAAS (120-138)
F6	probability	Probability of missed detection for most likely failed satellite
F7	estimate	Estimate of bias in meters on most likely failed satellite
F8	bias	Standard deviation of bias estimate
F9		Checksum

Example:

*$GPGBS,233618.00,-0.2063,-0.0220,-0.4760,14,0.0001,- 2.4018, 8.5704 *65*

$GPGGA

This output message reports position and fix related status information and is in compliance with NMEA-0183 Standards version 3.0, unless Field 14 is set to NCT Station ID. NCT Station ID is a C-Nav proprietary format. Note that the Navigation Mode in Field 14 is the same as that of message 0xB1,W22.

Output Format:	$GPGGA,time,lat,N/S,lon,E/W,quality,used,hdop,alt,M,separation,M,age,id*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	Lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F3	N/S	Direction of latitude (N=north, S=south)
F4	Lon	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)
F5	E/W	Direction of longitude (E=east, W=west)
F6	quality	Quality of the position fix (0 to 8) 0 = invalid solution 1 = Standalone GPS fix 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic 5 = Float RTK 6 = estimated (dead reckoning) 7 = Manual input mode 8 = Simulation mode
F7	used	Number of used satellites in the position fix
F8	hdop	Horizontal dilution of precision
F9	Alt	Altitude above mean-sea-level (geoidal height) in meters
F10	M	Units for altitude (M=meters)
F11	separation	Geoidal separation (difference between the WGS-84 earth ellipsoid and mean-sea-level, where "-" means mean-sea-level is below ellipsoid) in meters.
F12	M	Units for geoidal separation (M=meters)
F13	age	Time since last dGPS data was received in seconds

Continued on next page…

F14	Id	The NMEA Station ID setting results in NMEA GGA message output that strictly conforms to the NMEA Standard v3.01.The NCT Station ID is a NavCom proprietary format that populates F14 as described in the Tables below. The NavCom proprietary input message 0x49, W13 sets F14 to NMEA Station ID or NCT Station ID. If 0x49, W13 B0 = 1, 3-digit integer as denoted as XYY, where X is the StarFire™ satellite beam in use, and YY is the GPS correction signal type being used (see Tables below). If 0x49, W13 B0 = 0, Reference station ID number (0000 – 1023)
F15		Checksum

Example:

*$GPGGA,032215.00,3713.870081,N,12148.058703,W,2,08,1.8,59.608,M, -33.440,M,8.0,0130*47*

NCT Format Field 14 (Beam Selection ID)

ID (X)	DOWNLINK BEAM
0	None selected, or error
1	PAC-E (98W)
2	IND-E (109E)
3	IND-W (25E)
4	PAC-C (142W)
5	PAC-W (143.5E)
6	AOR-E (15.5W)
7	- reserved -
8	- reserved -
9	Forced to unknown frequency (Manual selection)

NCT Format Field 14 (Navigation Mode)

ID (YY)	GPS CORRECTION SIGNAL
00	Non dGPS
01	dGPS, RTCM type 1, 3, or 9, Single Freq
02	WAAS/EGNOS, Single Freq., (See GSA for SBAS ID in use)
03	Reserved
04	Reserved
05	Reserved
06	StarFire RTG, Single Freq. (no 'Tide' Adjustment)

$GPGLL

This output message reports geographic position (latitude and longitude) information and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGLL,lat,N/S,lon,E/W,time,status*checksum	
Field#	Field Name	Description
F1	Lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F2	N/S	Direction of latitude (N=north, S=south)
F3	lon	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)
F4	E/W	Direction of longitude (E=east, W=west)
F5	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F6	status	Status V = void (invalid data) A = active (valid data)
F7		Checksum

Example:

*$GPGLL,3713.870070,N,12148.058706,W,032618.00,A,D*7C*

$GPGRS

This output message is used to support Receiver Autonomous Integrity Monitoring (RAIM), and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGRS,time,mode,residual*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	mode	Mode 0 = residuals were used to calculate the position given in the matching GGA or GNS sentence 1 = residuals were recomputed after the GGA or GNS position was computed
F3	residuals	[1,2] Range residuals in meters for satellites used in the navigation solution. [3] Order must match order of the satellite ID numbers in GSA. When GRS is used GSA and GSV are generally required.
F4		Checksum

Example:

*$GPGRS,021733.00,0,0.4,1.8,-0.2,-0.3,-0.8,0.2,0.3,0.3,0.9,-0.7,1.1,-0.2 *4C*

[1] If the range residual exceeds ±99.9 meters, then the decimal part is dropped, resulting in a integer (-103.7 becomes -103). The maximum value for this field is ±999.

[2] The sense or sign of the range residual is determined by the order of parameters used in calculation. The expected order is:
range residual = calculated range – measured range.

[3] When multiple GRS sentences are being sent then their order of transmission must match the order of corresponding GSA sentences. Listeners shall keep track of pairs of GSA and GRS sentences and discard data if pairs are incomplete.

$GPGSA

This output message reports 2D/3D solution mode, DOP values and active satellite information, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGSA,mode,solution,used,pdop,hdop,vdop*checksum	
Field#	Field Name	Description
F1	mode	Mode M = manual solution (forced to operate in 2D or 3D mode) A = automatic (automatically switches between 2D and 3D)
F2	solution	Solution 1 = fix not available 2 = 2D 3 = 3D
F3	used	PRN of satellites used in navigation solution (12 fields, null for empty fields)
F4	pdop	Dilution of position
F5	hdop	Horizontal dilution of position
F6	vdop	Vertical dilution of position
F7		Checksum

Example:

*$GPGSA,A,3,03,08,13,16,20,23,25,27,,,,,2.4,1.4,1.9*36*

$GPGST

This output message reports pseudorange noise statistic information, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGST,time,rms,majoraxis,minoraxis,orientation,laterr,lonerr,alterr*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	rms	Total RMS standard deviation of ranges inputs to the navigation solution
F3	majoraxis	Standard deviation of semi-major axis of error ellipse in meters
F4	minoraxis	Standard deviation of semi-minor axis of error ellipse in meters
F5	orientation	Orientation of semi-major axis of error ellipse in true north degrees (0 to 180º)
F6	laterr	Standard deviation of latitude error in meters
F7	lonerr	Standard deviation of longitude error in meters
F8	alterr	Standard deviation of altitude error in meters
F9		Checksum

Example:

*$GPGST,032746.00,22236.0738,0.0552,0.0355,019.4414,0.0543,0.0368,0.0991*6A*

$GPGSV

This output message reports data associated with satellites in view, based on almanac data. Data includes PRN number, elevation, azimuth and SNR values. Note that one GSV sentence can only provide data for up to 4 satellites, so several sentences may be required for full “satellite in view” information. The format for this message is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPGSV,total,message,totalsv,prn1,elev1,azim1,snr1,.....,prn4,elev4,azim4,snr4*checksum	
Field#	Field Name	Description
F1	Total	Total number of messages for full information
F2	Message	Message number
F3	Totalsv	Total number of satellites in view that will be included in the messages (up to 4 satellites per message)
F4	Prn	Satellite PRN number
F5	Elev	Elevation for the corresponding satellite in degrees (0 to 90)
F6	Azim	Azimuth for the corresponding satellite in degrees (0 to 359)
F7	Snr	Signal to Noise ratio for the corresponding satellite
F8		Checksum

Examples:

*$GPGSV,3,1,11,13,68,347,50,23,66,87,50,25,56,40,0,27,45,277,46*78*
*$GPGSV,3,2,11,16,23,44,45,20,22,174,36,08,21,259,38,03,21,103,36*43*
*$GPGSV,3,3,11,19,09,128,32,04,05,266,34,02,01,301,30,,,,*44*

$GPRMC

This output message reports minimum recommended GPS information, including position, velocity, and time information, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPRMC,time,status,lat,N/S,lon,E/W,speed,course,date,variation,E/W,mode*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	status	Status V = void (invalid data) A = active (valid data) Value set to V for all modes listed in F12 except for A and D
F3	Lat	Latitude in degrees and decimal minutes (ddmm.mmmmmm) (0000.000000 to 8959.999999)
F4	N/S	Direction of latitude (N=north, S=south)
F5	long	Longitude in degrees and decimal minutes (dddmm.mmmmmm) (00000.000000 to 17959.999999)
F6	E/W	Direction of longitude (E=east, W=west)
F7	speed	Speed over ground in knots
F8	course	Course over ground in degrees true (0 to 359.9)
F9	date	Current date in the format ddmmyy
F10	Variation	Magnetic variation in degrees
F11	E/W	Direction of variation (E=east, W=west)
F12	mode	Position mode indicator A = autonomous D = DGPS E = Estimated (dead reckoning) S = Simulator N = Data not valid
F13		Checksum

Example:

*$GPRMC,033341.00,A,3713.870096,N,12148.058706,W,0.03,0.0,180407,0.0,E,D*19*

$GPVTG

This output message reports velocity and course over ground information, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPVTG,track,T,track,M,speed,N,speed,K,mode*checksum	
Field#	Field Name	Description
F1	track	True track (course over ground) in degrees (0 to 359.9)
F2	T	True track orientation (T=true north)
F3	track	Magnetic track in degrees (0 to 359.9)
F4	M	Magnetic track orientation (M=magnetic north)
F5	speed	Speed over ground in knots (0 to 1000)
F6	N	Speed over ground units (N=knots)
F7	speed	Speed over ground in kilometers (0 to 1852)
F8	K	Speed over ground units (K=km/h (kilometers/hour))
F9	mode	Position mode indicator A = autonomous D = DGPS E = Estimated (dead reckoning) S = Simulator N = Data not valid
F10		Checksum

Example:

*$GPVTG,0.0,T,,M,0.03,N,0.06,K,D*0D*

$GPZDA

This output message reports date and time information, and is in compliance with NMEA-0183 Standards version 3.0.

Output Format:	$GPZDA,time,day,month,year,offset_hour,offset_min*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	day	Current day (01 to 31)
F3	month	Current month (01 to 12)
F4	year	Current year (0000 to 9999)
F5	offset_hour	Local zone hours (-13 to +13)
F6	offset_min	Local zone minutes (00 to 59)
F7		Checksum

Example:

*$GPZDA,035751.00,18,04,2007,00,00*6B*

$PNCTSET

This output message reports C-Nav's proprietary SET (solid earth tides), PT (polar tides) and Ocean Loading values. It is a C-Nav proprietary NMEA type message, and it conforms to the header, checksum and electrical characteristics of a standard NMEA string, but is not recognized by the NMEA governing body as an officially sanctioned message.

Output Format:	$PNCTSET,SET_dN,SET_dE,SET_dU,PT_dN,PT_dE,PT_dU,OL_dN,OL_dE,OL_dU*checksum	
Field#	Field Name	Description
F1	time	UTC time for position fix in hours, minutes, seconds (hhmmss.ss) (000000.00 to 235959.99)
F2	SET dN	Solid earth tides, delta North (meters)
F3	SET dE	Solid earth tides, delta East (meters)
F4	SET dU	Solid earth tides, delta Up (meters)
F5	PT dN	Polar Tides, delta North (meters)
F6	PT dE	Polar Tides, delta East (meters)
F7	PT dU	Polar Tides, delta Up (meters)
F8	Ocean Loading dN	Ocean Loading, delta North (meters)
F9	Ocean Loading dE	Ocean Loading, delta East (meters)
F10	Ocean Loading dU	Ocean Loading, delta Up (meters)
F11		Checksum

Example:

*$PNCTSET,214040.00,-0.060,-0.018,0.110,,,,,,*47*

Appendix E
C-Nav L-band Correction Signal

The C-Nav1010 GPS Receiver can obtain C-Nav Corrections Service signals from six (6) separate and independent geo-stationary communication satellites.

The Satellite Based Augmentation System (SBAS) signals obtained from geo-stationary communication satellites are selected by GPS L1 PRN ID.

The L-band Identifiers for the tracking and decoding of these C-Nav Corrections Service corrections by the C-Nav1010 GPS Receiver are as follows:

***Table E1**: L-band Correction Identifiers and Modes*

L-band ID	Name	RTG	SBAS	Geo-stationary Position
AM-1	Americas Net-1	YES	NO	97.65° W
EUA-1	Europe/ Africa Net-1	YES	NO	25° E
PAC-1	Asia/ Pacific Net-1	YES	NO	109° E
AM-2	Americas Net-2	YES	NO	142° W
EUA-2	Europe/ Africa Net-2	YES	NO	15.5° W
PAC-2	Asia/ Pacific Net-2	YES	NO	143.5° E
GPS L1 (PRN: 135)	PanAm Sat Galaxy 15	NO	WAAS	133° W

GPS L1 (PRN: 138)	TeleSat ANIK	NO	WAAS	107.3° W
GPS L1 (PRN: 120)	AOR-E	NO	EGNOS	15.5° W
GPS L1 (PRN: 124)	ARTEMIS	NO	EGNOS	21.5° E
GPS L1 (PRN: 126)	IOR-W	NO	EGNOS	25° E
GPS L1 (PRN: 131)	IOR-E	NO	EGNOS	64° E
GPS L1 (PRN: 129)	MTSAT-1R	NO	MSAS	140° E
GPS L1 (PRN: 137)	MTSAT-2	NO	MSAS	145° E

Note –See the C-Nav L-band Communication Satellite Locator utility: *www.cnavgnss.com/calculator*

Appendix F CE Declaration of Conformity

Declaration of Conformity
Declaration de Conformité
Konformitätserklärung

(in accordance with EN ISO/IEC 17050-1)

We / Nous /Wir **NavCom Technology, Inc, Torrance, CA 90503 (USA)**

declare under our sole responsibility that the product
déclarons sous notre seule responsabilité que le produit
erklären in alleiniger Verantwortung, dass das Produkt

SF-2110
(SF-2110M, SF-2110R, C-Nav1010M, C-Nav1010R)

to which this declaration relates is in conformity with the following standards
auquel se réfère cette déclaration est conforme aux normes
auf das sich diese Erklärung bezieht, mit den folgenden Normen übereinstimmt

EN55022 Class B
EN61000-3-2
EN61000-3-3
EN55024:1998
EN61000-4-2
EN61000-4-3
EN61000-4-4
EN61000-4-5
EN61000-4-6
EN61000-4-8
EN61000-4-11

following the provisions of Directive
conformément aux dispositions de Directive
gemäss den Bestimmungen der Richtlinie

Electromagnetic Compatibility (EMC) Directive 2004/108/EC

NavCom Technology Inc, Torrance, January 28, 2008

Robert P. Zimmerman

Robert Zimmerman
Director of Hardware Engineering

NAVCOM TECHNOLOGY, INC.
A John Deere Company
20780 Madrona Avenue
Torrance, CA 90503, USA
Phone +1 (310) 381-2000
Fax +1 (310) 381-2001
www.navcomtech.com

A John Deere Company

Appendix G Glossary

Abbreviations

2dRMS –	Twice the distance Root Mean Square
A/S –	Antispoofing
APC –	Antenna Phase Center
BER -	Bit Error Rate
bps –	bits per second
BSW –	British Standard Whitworth
C/A –	Coarse/Acquisition
CEP –	Circular Error Probable
CDU –	Control Display Unit
COM –	Communication
CMR -	Compact Measurement Record
Db -	Decibel
DCE –	Data Communications Equipment
Deg -	Degree
DGPS –	Differential Global Positioning System
DOP –	Dilution of Precision
DTE –	Data Terminal Equipment
ECDIS –	Electronic Chart Display & Information System
ECEF –	Earth Centered, Earth Fixed
EGNOS –	European Geostationary Navigation Overlay Service

FCC –	Federal Communications Commission (U.S.)
GAGAN -	GPS Aided Geo Augmented Navigation
GDOP –	Geometric Dilution of Precision
GIS –	Geographic Information System
GMT –	Greenwich Mean Time
GNSS –	Global Navigation Satellite System
GPS –	Global Positioning System
HDOP –	Horizontal Dilution of Precision
HF –	High Frequency
HOW –	Hand Over Word
Hz –	Hertz
I/O –	Input/Output
IGN -	Ignition
IMO –	International Maritime Organization
INMARSAT –	International Maritime Satellite Consortium, Ltd.
INS –	Inertial Navigation System
IODC –	Issue of Data, Clock
ITRF –	International Terrestrial Reference Frame
JPL –	Jet Propulsion Laboratory
Kbps –	Kilobits per second
KHz -	Kilohertz
LAN -	Local Area Network
Lat –	Latitude
LCD -	Liquid Crystal Display

LED –	Light Emitting Diode
LES –	Land Earth Station
LF –	Low Frequency
Long –	Longitude
LORAN –	Long Range Navigation System
LNA -	Low Noise Amplifier
MSAS -	MTSAT Satellite-based Augmentation System
MSL –	Mean Sea Level
NAD27 –	North American Datum 1927
NAD83 –	North American Datum 1983
NASA –	National Aeronautics and Space Administration
Nav –	Navigation
NGS –	National Geodetic Survey
NOAA –	National Oceanic and Atmospheric Administration (U.S.)
P/N –	Part Number
PCM –	Pulse Code Modulation
PDOP –	Positional Dilution of Precision
PPS –	Precise Positioning Service
prn –	pseudorandom noise
PVT –	Position, Velocity, Time
RAIM –	Receiver Autonomous Integrity Monitoring
RHCP –	Right-hand Circular Polarization
RINEX –	Receiver Independent Exchange

RMS –	Root Mean Square
RTCM -	Radio Technical Commission for Maritime Services
RTG –	Real-time Gypsy
RTK –	Real-time Kinematic
S/A –	Selective Availability
SBAS –	Satellite Based Augmentation System
SEP –	Spherical Error Probable
SI –	International System of Units
SNR –	Signal-to-Noise Ratio
SPS –	Standard Positioning Service
SSR –	Spread Spectrum Radio
SV –	Space Vehicle
TDOP –	Time Dilution of Precision
UHF –	Ultra High Frequency
USB -	Universal Serial Bus
USGS –	U.S. Geological Survey
UTC –	Universal Time Coordinated
VDOP –	Vertical Dilution of Precision
VHF –	Very High Frequency
WAAS –	Wide Area Augmentation System
WADGPS –	Wide Area Differential Global Positioning System
WDOP –	Weighted Dilution of Precision
WGS84 –	World Geodetic System 1984

Definitions

.yym files see meteorological files (where yy = two digit year data was collected).

.yyn files see navigation files (where yy = two digit year data was collected

.yyo files see observation files (where yy = two digit year data was collected).

Absolute Positioning is the ability of a GPS receiver to produce positional values without another receiver for reference.

Accuracy is the degree of conformity of a measured or calculated quantity to a standard or true value. Accuracy is therefore related to the quality of the results.

Almanac is found in subframe 5 of the Navigation Message. It is a data file that helps the receiver track, and lock-on to satellites as it contains a summary of orbital parameters for all GPS satellites. The almanac can be acquired from any GPS satellite.

Altitude is the vertical distance above the ellipsoid or geoid. It is always stored as height above ellipsoid in the GPS receiver but can be displayed as height above ellipsoid (HAE) or height above mean sea level (MSL).

Ambiguity is the unknown number of whole carrier wavelengths between satellite and receiver.

Antenna is a device used to collect and amplify the electromagnetic GPS signals broadcast by a satellite. These electromagnetic waves are then converted into electrical currents that are decoded by the receiver. Patch, or Microstrip antennas are most commonly used in GPS.

Antenna Phase Center (APC) is the point in an antenna where the GPS signal from the satellites is received. The height above ground of the APC must be measured accurately to ensure accurate GPS readings. The APC height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the APC.

Antispoofing (A/S) is an encryption technique developed by the US Department of Defense (DoD) that when implemented, denies access to the P-Code by any unauthorized users. With Antispoofing on, the user will need a DoD issued “key” in order to gain access to the P-Code.

Apogee is the point in the orbit of a satellite about the earth that is the greatest distance from the center of the earth.

Autocorrelation in reference to code is a plot of the scalar product of the noise sequence with a delayed copy of itself.

Autonomous positioning (GPS) is a mode of operation in which a GPS receiver computes position fixes in real time from satellite data alone, without reference to data supplied by a reference station or orbital clock corrections. Autonomous positioning is typically the least precise positioning procedure a GPS receiver can perform, yielding position fixes that are precise to 100 meters with Selective Availability on, and 30 meters with S/A off.

Average Deviation is a measure of variability in a data set but it is more robust than standard deviation. It is not related to the bell-shaped curve. It is the average of the absolute deviations of the values from the mean. The data values are subtracted from the mean producing a list of deviations from the mean. The

deviations are not squared like they are for the standard deviation; the absolute values of the deviations are used.

Azimuth the azimuth of a line is its direction as given by the angle between the meridian and the line measured in a clockwise direction from the north branch of the meridian.

Bad Packets refer to the number of bad C-Nav Corrections Service packets received since the unit was turned on.

Bandwidth is a measure of the width of the frequency spectrum of a signal expressed in Hertz.

Baseline is the resultant three-dimensional vector (V) between any two stations from which simultaneous GPS data have been collected and processed. Generally given in earth-centered Cartesian coordinates where: $V=(\Delta x, \Delta y, \Delta z)$

Base station see reference station.

Baud Rate (*bits per second*) is the number of bits sent or received each second. For example, a baud rate of 9600 means there is a data flow of 9600 bits each second. One character roughly equals 10 bits.

Beat Frequency is either of the two additional frequencies obtained when two signals of two frequencies are mixed, equal to the sum or difference of the original frequencies.

Binary Biphase Modulation is a phase change on a constant frequency carrier of either 0 or 180 degrees. These represent the binary digits 0 and 1, respectively.

Binary Code is a system used in communication where selected strings of 0’s and 1’s are assigned definite meanings.

Binary Pulse Code Modulation is a two-state phase modulation using a string of binary numbers or codes. The coding is generally represented by 1 and 0 with definite meanings attached to each.

Bits per second see baud rate.

Broadcast Ephemeris is the ephemeris broadcast by the GPS satellites.

British Standard Whitworth (BSW) is a type of coarse screw thread. A 5/8" diameter BSW is the standard mount for survey instruments. (1" Mount included).

C/A code see Coarse Acquisition code.

CAN BUS is a balanced (differential) 2-wire interface that uses an asynchronous transmission scheme. Often used for communications in vehicular applications.

Carrier is a high-frequency radio wave having at least one characteristic (frequency, amplitude, or phase), which may be varied by modulation from an accepted value. In general, the carrier wavelength is much shorter than the wavelength of the codes.

Carrier Beat Phase is the difference between the phase of the incoming Doppler shifted satellite carrier signal and the phase of the nominally constant reference frequency generated in the receiver.

Channel a channel of a GPS receiver consists of the circuitry necessary to receive the signal for a single GPS satellite.

Chip *a*. The minimum transition time interval for individual bits of either a 0 or 1 in a binary pulse code usually transmitted in a pseudo-random sequence. *b*. A tiny square piece of thin semiconductor material on which an integrated circuit is formed or is to be formed.

Circular Error Probable (CEP) is a measurement of precision using standard deviation that is applicable in

horizontal stations. Probability for CEP is 50%, meaning that if 100 observations are made, half of them will be within the circular error probable with
Radius = 0.5887 ($\sigma x + \sigma y$)

Civilian code see Coarse Acquisition code.

Clock Bias is the difference between GPS Time and UTC.

Coarse Acquisition code (C/A or Civilian code) is the pseudo-random code generated by GPS satellites. It is intended for civilian use and the accuracy of readings using this code can be degraded if selective availability (S/A) is introduced by the US Department of Defense.

Collimate is to physically align a survey target or antenna over a mark.

COM is the shortened form of the word Communications. Indicates a data communications port to/from the GPS sensor to a controller or data collection device.

Compact Measurement Record (CMR/CMR+) is a standard format for DGPS corrections used to transmit corrections from a reference station to rover sensors. See Related Standards in Notices.

Controller is a device consisting of hardware and software used to communicate and manipulate the I/O functions of the GPS sensor.

Control Point is a point to which coordinates have been assigned. These coordinates can then be held fixed and are used in other dependant surveys.

Control Segment is a worldwide network of GPS monitoring and control stations that ensure the accuracy of the GPS satellite orbits and operation of their atomic clocks. The original control segment consists of control

facilities in Diego Garcia, Ascension Island, Kwajalein, and Hawaii, with a master control station at the Consolidated Space Operations Center (CSPOC) at Colorado Springs, Colorado.

Convergence Period (C-Nav) is the time necessary for the received C-Nav corrections to be applied and the position filtered to optimal performance. The convergence period is typically 30 to 45 minutes to achieve decimeter accuracy.

Cycle Ambiguity see Ambiguity.

Cycle Slip is a discontinuity in measured carrier beat phase resulting from a temporary loss of lock in the carrier-tracking loop of a GPS receiver.

Datum A reference datum is a known and constant surface, which can be used to describe the location of unknown points. Geodetic datums define the size and shape of the earth and the origin and orientation of the coordinate systems used to map the earth.

DB9P a type of electrical connector containing 9 contacts. The P indicates a plug pin (male).

DB9S a type of electrical connector containing 9 contacts. The S indicates a slot pin (female).

DCE Data Communications Equipment. Defined pin assignments based on the IEEE RS-232 signaling standard. See *Figure G-1*:

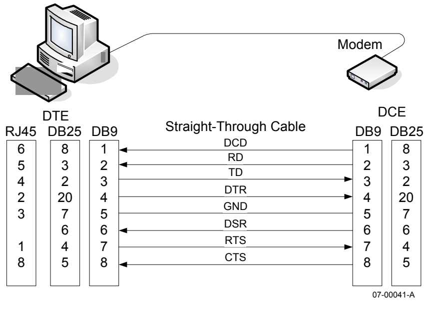


***Figure G1**: DTE to DCE RS-232 Pin Assignments*

Deflection of the Vertical is the angle between the perpendicular to the geoid (plumb line) and the perpendicular to the ellipsoid.

DGPS see Differential GPS.

Differencing is a technique used in baseline processing to resolve the integer cycle ambiguity and to reduce a number of error sources including oscillator variations and atmospheric and orbital modeling errors. This technique “differences” the measurement of the carrier beat phase across time, frequency, receivers, satellites, or any combination of these. The most popular differences are single, double and triple.

Differential GPS (DGPS) is a positioning procedure that uses two receivers, a rover at an unknown location and a reference station at a known, fixed location. The reference station computes corrections based on the actual and observed ranges to the satellites being tracked. The coordinates of the unknown location can be computed with sub-meter level precision by applying these corrections to the satellite data received by the rover.

Dilution of Precision (DOP) is a class of measures of the magnitude of error in GPS position fixes due to the orientation of the GPS satellites with respect to the GPS receiver. There are several DOP’s to measure different components of the error. Note: this is a unit-less value. See also PDOP.

Doppler Aiding is a signal processing strategy that uses measured Doppler shifts to help the receiver smoothly track the GPS signal, allowing more precise velocity and position measurement.

Doppler Shift is the apparent change in frequency of a received signal due to the rate of change of the distance between the transmitter and receiver.

Double Difference between receivers and between satellites is found by differencing the single difference for one satellite with the single difference for another satellite where both single differences are from the same epoch.

Dual-Frequency is a type of GPS receiver that uses both L1 and L2 signals from GPS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.

Dynamic Mode when a GPS receiver operates in dynamic mode, it assumes that it is in motion and certain algorithms for GPS position fixing are enabled in order to calculate a tighter position fix.

Dynamic Positioning (GPS) is the determination of the position of a moving receiver such as one mounted on a boat. Generally, each set of coordinates is computed from a single data sample. The GPS was originally conceived for dynamic positioning of a single receiver, however, it may be used in a differential mode to increase relative accuracy.

Eccentricity is the ratio of the distance from the center of an ellipse to its focus on the semi-major axis.

Elevation is the distance above or below Local Vertical Datum.

Elevation Mask the lowest elevation, in degrees, at which a receiver can track a satellite. Measured from the horizon to zenith, 0º to 90º.

Ellipsoid is a mathematical model approximating the earth’s surface, generated by rotating an ellipse on its

minor axis. GPS positions are computed relative to the WGS-84 ellipsoid. An ellipsoid has a smooth surface, which does not match the earth's geoidal surface closely, so GPS altitude measurements can contain a large vertical error component. Conventionally surveyed positions usually reference a geoid, which has an undulating surface and approximates the earth's surface more closely to minimize altitude errors.

Ephemeris is a tabulation of the positions of all GPS satellites at given points in time.

Epoch is a period of time or a date selected as a point of reference.

Error Ellipse is a statistical measure of the positional error at a given point computed from the propagation of all errors affecting the position solution and expressed by its semi-major and semi-minor axis (vectors of greatest and least magnitude) and the covariance (rotation angle in the reference coordinate system). Two-dimensional errors are typically propagated at one standard deviation (39.4% probability that the positioning lies on or within the ellipse) or 2.1447 times the standard deviation (95% confidence) level.

European Geostationary Navigation Overlay Service (EGNOS) a European satellite system used to augment the two military satellite navigation systems now operating, the US GPS and Russian GLONASS systems.

Fractional Instantaneous Phase Measurement is a measurement of the carrier beat phase that does not include any integer cycle count.

Frequency Band is a range of frequencies in a region of the electromagnetic spectrum.

Frequency Spectrum is the distribution of signal amplitudes as a function of frequency of the constituent signal waves.

Galileo is the navigation satellite system currently being developed and implemented by the European Space Agency, the European Union. Initial operation is planned for 2008.

Geodetic Leveling Network is a network of vertical control or benchmarks whose heights are known as accurately as possible, and whose horizontal position is known only approximately.

Geoid is the gravity-equipotential surface that best approximates mean sea level over the entire surface of the earth. The surface of a geoid is too irregular to use for GPS readings, which are measured relative to an ellipsoid. Conventionally surveyed positions reference a geoid. Calculating the distance between the geoid and ellipsoid at each position and subtracting this from the GPS altitude measurement can obtain more accurate GPS readings.

Geoidal Height is the undulation of the geoid above or below the reference ellipsoid.

Geographical Information System (GIS) is a computer system capable of assembling, storing, manipulating, updating, analyzing and displaying geographically referenced information, i.e. data identified according to their locations. GIS technology can be used for scientific investigations, resource management, and development planning. GIS software is used to display, edit, query and analyze all the graphical objects and their associated information.

Global Positioning System (GPS) geometrically, there can only be one point in space, which is the correct distance from each of four known points. GPS measures the distance from a point to at least four

satellites from a constellation of 24 NAVSTAR satellites orbiting the earth at a very high altitude (approximately 20,200km). These distances are used to calculate the point's position.

GPS Aided Geo Augmented Navigation (GAGAN) is an Indian satellite system that provides a set of corrections for the GPS satellites, which are valid for the Indian region. They incorporate satellite orbit and clock corrections.

GPS Time is a measure of time. GPS time is based on UTC, but does not add periodic 'leap seconds' to correct for changes in the earth's period of rotation. As of April 2008 GPS time is 14 seconds ahead of UTC.

Greenwich Mean Time (GMT) is the local time of the 0° meridian passing through Greenwich, England.

Handover Word is the word in the GPS message that contains time synchronization information for the transfer from the C/A-code to the P-code.

Horizontal Geodetic Network is a network for which the horizontal, coordinate, latitude, and longitude of the control points in the network are determined as accurately as possible, and heights are known only approximately.

Independent Baseline those baselines that provide a unique position solution for a given station.

Integer-cycle Ambiguity is the unknown number of whole carrier cycles between the satellite and the receiver.

Ionosphere is the region of the earth's atmosphere between the stratosphere and the exosphere approximately 50 to 250 miles above the earth's surface

Ionospheric Refraction Delay is a delay in the propagation of the GPS signal caused by the signal traveling through the ionosphere.

Issue of Data, Clock (IODC) indicates the issue number of the data set and thereby provides the user with a convenient means of detecting any change in the correction parameters. The transmitted IODC will be different from any value transmitted by the satellite during the preceding seven days.

Kalman Filtering is a linear system in which the mean squared error between the desired output and the actual output is minimized when the input is a random signal generated by white noise. The Kalman filter looks at a target to remove the effects of the noise and get a good estimate of the location of the target at the present time (filtering), at a future time (prediction), or at a time in the past (interpolation or smoothing). The Kalman filter is a recursive estimator with two phases: predict and update. The predict phase uses the estimate from a previous state to produce an estimate of the current state. The update phase uses the current state measurements to arrive at a new more accurate estimate.

L-band is the group of radio frequencies extending from approximately 400MHz to approximately 1600MHz. The GPS carrier frequencies L1 (1575.4MHz) and L2 (1227.6 MHz) are in the L-band range.

L1 carrier frequency is the primary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1575.42MHz. It is modulated by C/A code, P-code, or Y-code, and a 50-bit/second navigation message. The bandwidth of this signal is 1.023MHz.

L2 carrier frequency is the secondary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1227.6MHz. It is modulated by P-code, or

Y-code, and a 50-bit/second navigation message. The bandwidth of this signal is 10.23MHz.

Land Earth Station (LES) is the point on the earth's surface where data is up linked to a satellite.

Latitude (lat) is the north/south component of the coordinate of a point on the surface on the earth; expressed in angular measurement from the plane of the equator to a line from the center of the earth to the point of interest. Often abbreviated as Lat.

Least Squares Adjustment is a mathematical technique used on data sets that attempts to find the number that provides the 'best fit' to the data. It does so by minimizing the sum of the squares of the residuals, which are the difference between the estimated 'best fit' and the data point squared. It is carried out using an iterative process. Furthermore, it is a method of determining the curve that best describes the relationship between expected and observed sets of data by minimizing the sums of the squares of deviation between observed and expected values.

LEMO is a type of data or power connector.

Logging Interval is the frequency at which positions generated by the receiver are logged to data files.

Longitude (long) is the east/west component of the coordinate of a point on the surface of the earth; expressed as an angular measurement from the plane that passes through the earth's axis of rotation and the 0° meridian and the plane that passes through the axis of rotation and the point of interest. Often abbreviated as Lon.

Mean Sea Level (MSL) is a vertical surface that represents sea level.

Meridian one of the lines joining the north and south poles at right angles to the equator, designated by degrees of longitude, from 0° at Greenwich to 180°.

Meteorological (.YYm) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A meteorological file contains atmospheric information.

Monitor Station is one of five worldwide stations maintained by the DoD and used in the GPS control segment to monitor and control satellite clock and orbital parameters. Corrections are calculated and uploaded to each satellite at least once per day. See Control Segment.

MTSAT Satellite-based Augmentation System (MSAS) is a Japanese satellite system that provides a set of corrections for the GPS satellites, which are valid for the Japanese region. They incorporate satellite orbit and clock corrections.

Multipath is a phenomenon whereby GPS signals from a satellite arrive at an antenna having traversed different paths. The signal traversing the longer path may have been reflected off one or more objects—the ground, a vehicle, boat, building or some other surface—and once received by the antenna, will yield a larger pseudo-range estimate and increase the error.

Multipath Error is a positioning error resulting from interference between radio waves that has traveled between the transmitter and the receiver by two paths of different electrical lengths.

Navigation Code uses the two GPS carrier waves and operates on a very low frequency (about 50Hz). This code communicates the GPS message (a string of data) from the GPS satellites to the GPS receivers on L1 and L2 carrier waves.

Navigation (.YYn) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. A navigation file contains satellite position and time information.

Navigation Message is the 1500-bit message broadcast by each satellite at 50bps on both L1 and L2 beacons. This message contains system time, clock correction parameters, ionospheric delay model parameters, and the vehicle's ephemeris and health. This information is used to process the GPS signal to obtain user position and velocity.

NAVSTAR is the name given to GPS satellites, originally manufactured by Rockwell International.

Observation (.YYo) files one of the three file types that make up the *RINEX* file format. Where YY indicates the last two digits of the year the data was collected. An observation file contains raw GPS position information.

P-code is the extremely long pseudo-random code generated by a GPS satellite. It is intended for use only by the U.S. military, so it can be encrypted to Y-code, and then denies unauthorized users access.

Parity is a method of detecting communication errors by adding an extra parity bit to a group of bits. The parity bit can be a 0 or 1 value so that every byte will add up to an odd or even number (depending on whether odd or even parity is chosen).

PDOP Mask is the highest PDOP value at which a receiver computes positions.

Perigee is the point in the orbit of a satellite about the earth that is the least distant from the center of the earth.

Phase Center is the point in an antenna where the GPS signal from the satellites is received. The height

above ground of the phase center must be measured accurately to ensure accurate GPS readings. The phase center height can be calculated by adding the height to an easily measured point, such as the base of the antenna mount, to the known distance between this point and the phase center.

Phase Lock is the technique where the phase of a signal is set to replicate the phase of a reference signal by comparing the phase of the two signals and then using the resultant phase difference to adjust the reference oscillator to eliminate the difference.

Phase Measurement is measurement expressed as a percentage of a portion of a wave (e.g. a sine wave). For example, a complete wavelength

Position is the latitude, longitude, and altitude of a point. An estimate of error is often associated with a position.

Position Dilution of Precision (PDOP) is a measure of the magnitude of Dilution of Position (DOP) errors in the x, y, and z coordinates.

Post-processing is a method of differential data correction, which compares data logged from a known reference point to data logged by a roving receiver over the same period of time. Variations in the position reported by the reference station can be used to correct the positions logged by the roving receiver. Post-processing is performed after the user collects the data and returns to the office, rather than in real time as data is logged, so it can use complex, calculations to achieve greater accuracy.

Precise code see P-code.

Precise Ephemeris is the ephemeris computed after the transmission of the satellite signal and based on

satellite tracking information. It is used in post-processing of collected GPS data.

Precision is the degree of agreement or repeatability among a series of individual measurements, values, or results. The precision of a numerical value can refer to the number of significant digits used to express a quantity or that an instrument can measure to. Precision is related to the quality of the operation through which the result is obtained.

PRN (Uppercase) typically indicates a GPS satellite number sequence from 1 – 32.

Projection is a mathematical formula that transforms feature locations between the earth's curved surface and a map's flat surface. A projected coordinate system includes the information needed to transform locations expressed as latitude values to x,y coordinates. Projections cause distortion in one or more of these spatial properties-distance, area, shape and direction.

Protected code see P-code.

Pseudo-Random Noise (*prn*) is a sequence of data that appears to be randomly distributed but can be exactly reproduced. Each GPS satellite transmits a unique PRN in its signals. GPS receivers use PRNs to identify and lock onto satellites and to compute their pseudoranges.

Pseudorange is the apparent distance from the reference station's antenna to a satellite, calculated by multiplying the time the signal takes to reach the antenna by the speed of light (radio waves travel at the speed of light). The actual distance, or range, is not exactly the same because various factors cause errors in the measurement.

Radio Technical Commission for Maritime Services (RTCM) is a standard format for Differential GPS

corrections used to transmit corrections from a base station to rovers. RTCM allows both real-time kinematic (RTK) data collection and post-processed differential data collection. RTCM SC-104 (RTCM Special Committee 104) is the most commonly used version of RTCM message.

Range is the distance between a satellite and a GPS receiver's antenna. The range is approximately equal to the pseudorange. However, errors can be introduced by atmospheric conditions, which slow down the radio waves, clock errors, irregularities in the satellite's orbit, and other factors. A GPS receiver's location can be determined if you know the ranges from the receiver to at least four GPS satellites. Geometrically, there can only be one point in space, which is the correct distance from each of four known points.

Real Time GIPSY (RTG) is a processing technique developed by NASA's Jet Propulsion Laboratory to provide a single set of real time global corrections for the GPS satellites.

Real-Time Kinematic (RTK) is a GPS system that yields very accurate 3D position fixes immediately in real-time. The base station transmits its GPS position to roving receivers as the receiver generates them, and the roving receivers use the base station readings to differentially correct their own positions. Accuracies of a few centimeters in all three dimensions are possible. RTK requires dual frequency GPS receivers and high speed radio modems.

Receiver Independent Exchange (RINEX) is a set of standard definitions and formats designed to be receiver or software manufacturer independent and to promote the free exchange of GPS data. The *RINEX* file format consists of separate files, the three most commonly used are:

Observation (.YYo) file,

Navigation (.YYn) file,

Meteorological (.YYm) files;

Where YY indicates the last two digits of the year the data was collected.

Reference station a reference station collects GPS data for a fixed, known location. Some of the errors in the GPS positions for this location can be applied to positions recorded at the same time by roving receivers which are relatively close to the reference station. A reference station is used to improve the quality and accuracy of GPS data collected by roving receivers.

Right Hand Circular Polarization (RHCP) is used to discriminate satellite signals. GPS signals are RHCP.

Root Mean Square (RMS) is a measurement of precision also applicable for horizontal stations. Probability for RMS is 68.3%, meaning that if 100 observations are made, 68 of them will be within the root mean square, 1 standard deviation.

Rover is any mobile GPS receiver and field computer collecting data in the field. A roving receiver's position can be differentially corrected relative to a stationary reference GPS receiver or by using GPS orbit and clock corrections from a SBAS such as the C-Nav Corrections Service.

Roving Receiver see rover

Satellite Based Augmentation System (SBAS) this is a more general term, which encompasses WAAS, C-Nav Corrections Service and EGNOS type corrections.

Satellite Constellation is the arrangement of a set of satellites in space.

Satellite Message is sometimes referred to as the Data (D) code. A low-frequency (50 Hz) stream of data on both carriers (L1 and L2) of the satellite signal. The stream of data is designed to inform the user about the health and position of the satellite. The satellite message can be decoded by the receiver and used for positioning in real time.

Selective Availability (S/A) is the deliberate degradation of the GPS signal by encrypting the P-code and dithering the satellite clock. When the US Department of Defense uses S/A, the signal contains errors, which can cause positions to be inaccurate by as much as 100 meters.

Signal-to-Noise Ratio (SNR) is a measure of a satellite's signal strength.

Single Difference between receivers is the instantaneous difference in the complete carrier beat phase measurements made at two receivers simultaneous observing the same signal.

Single-frequency is a type of receiver that only uses the L1 GPS signal. There is no compensation for ionospheric effects. The C-Nav1010 is a single frequency receiver.

Space Segment is the portion of the GPS system with major components in space (e.g., satellites).

Space Vehicle (SV) a GPS satellite.

Spread Spectrum Radio (SSR) is a radio that uses wide band, noise like (pseudo-noise) signals that are hard to detect, intercept, jam, or demodulate making any data transmitted secure. Because spread spectrum signals are so wide, they can be transmitted at much lower spectral power density (Watts per Hertz), than narrow band signals.

Standard Deviation is a measure of how widely values are dispersed from the mean. The larger the standard deviation is, the more spread out the values are from the mean. It is the square root of the average squared deviations of each of the values from the mean.

Time Tag is when a time value is appended to an actual measurement.

Triple Difference between receivers, between satellites, and between epochs (time) is the difference between a double difference at one epoch and the same double difference at the following epoch.

Troposphere is the inner layer of the atmosphere, located between 6 and 12 miles above the earth's surface.

Twice Distance Root Mean Square (2dRMS) is a measurement that varies in its probability from 95.4% to 98.2%, meaning that if 100 observations are taken, between 95 and 98 of those observations will be within the 2dRMS where approximation = 2σ

Universal Time Coordinated (UTC) a time standard maintained by the US Naval Observatory, based on local solar mean time at the Greenwich meridian. GPS time is based on UTC.

User Segment is the portion of the GPS system with major components that can be interfaced by the user (e.g., GPS receivers).

Wide Area Augmentation System (WAAS) is a set of corrections for the GPS satellites, which are valid for the Americas region. They incorporate satellite orbit and clock corrections.

Wide Area Differential GPS (WADGPS) is a set of corrections for the GPS satellites, which are valid for a wide geographic area.

World Geodetic System 1984 (WGS84) is the current standard datum for global positioning and surveying. The WGS-84 is based on the GRS-80 ellipsoid.

Y-code is the name given to encrypted P-code when the U.S. Department of Defense uses selective availability.

Z-count Word is the GPS satellite clock time at the leading edge of the data subframe of the transmitted GPS message.

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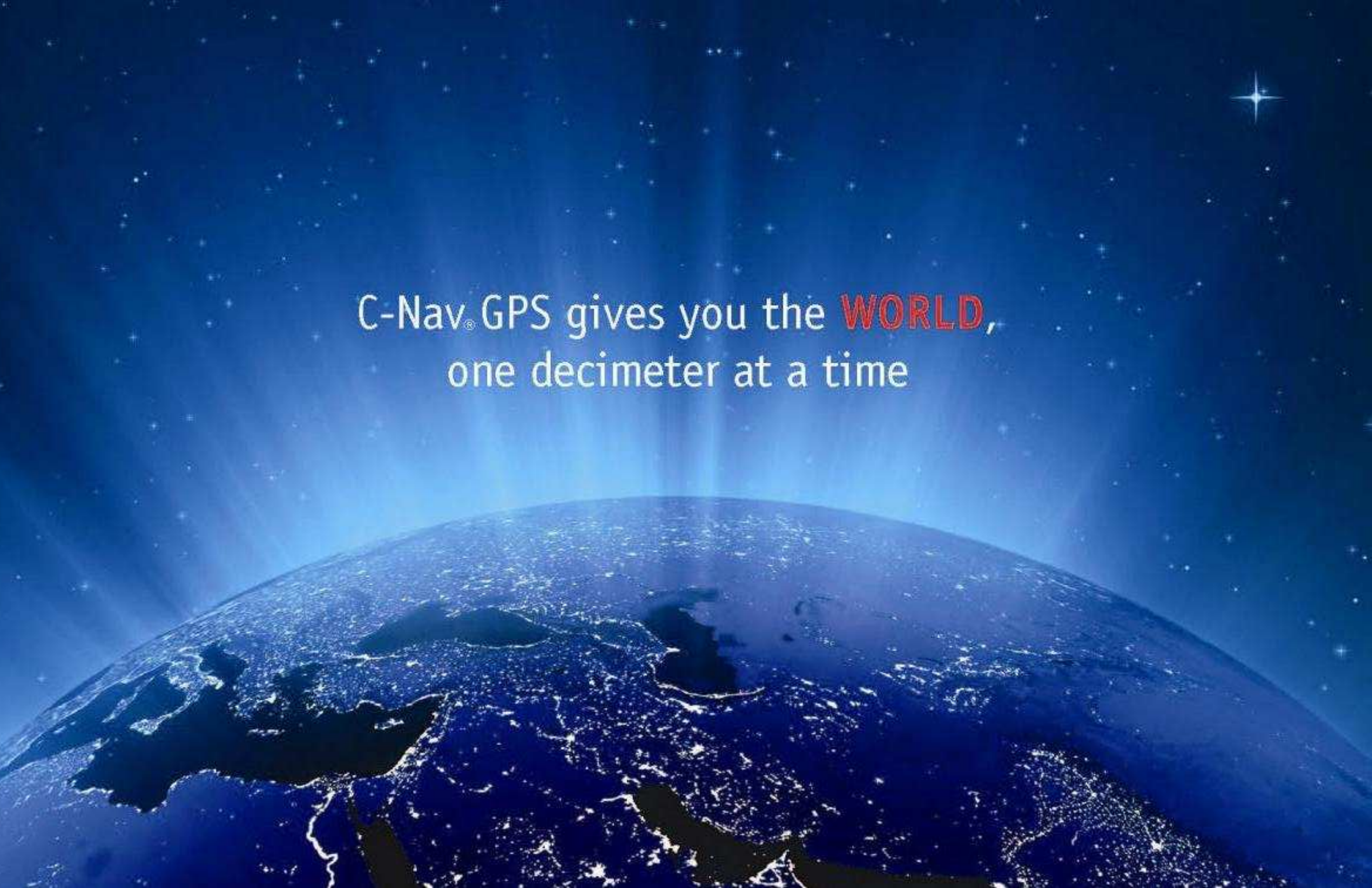
C-Nav® GPS gives you the WORLD,
one decimeter at a time